PREDICTION OF ANASTOMOTIC LEAKS IN GASTROINTESTINAL SURGERIES USING "EVALUATION OF PHYSIOLOGICAL ABILITY AND SURGICAL STRESS SCORING SYSTEM"

(E-PASS SCORING SYSTEM)

Dissertation submitted in

Partial fulfilment of the regulations required for the award of

M.S. DEGREE

In

GENERAL SURGERY

THE TAMILNADU

DR. M.G.R. MEDICAL UNIVERSITY

CHENNAI

APRIL 2015

DECLARATION

I hereby declare that the dissertation entitled **"PREDICTION OF ANASTOMOTIC LEAKS IN GASTRO INTESTINAL SURGERIES USING EVALUATION OF PHYSIOLOGICAL ABILITY AND SURGICAL STRESS (E-PASS) SCORING SYSTEM"** was done by me in the Department of General Surgery at Coimbatore medical college hospital during the period from September 2013 to September 2014 under the guidance and supervision of Prof. Dr. G. Ravindran M.S., Department of General Surgery, Coimbatore medical college hospital. This dissertation is submitted to the Tamilnadu Dr. M.G.R Medical University, Chennai towards partial fulfilment of requirement for the award of M.S. Degree in General Surgery. I have not submitted this dissertation on any previous occasion to any university for award of any degree.

Place:

Date: **Dr. B. Pradeep**

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This is to certify that the dissertation entitled **"PREDICTION OF ANASTOMOTIC LEAK IN GASTROINTESTINAL SURGERIES USING EVALUATION OF PHYSIOLOGICAL ABILITY AND SURGICAL STRESS (E-PASS) SCORING SYSTEM"** is a record of bonafide work done by **Dr. B. PRADEEP** under the guidance of **Prof. Dr. G. Ravindran M.S.,** Department of General Surgery, Coimbatore Medical College and Hospital. This is submitted for partial fulfilment of the regulations for the award of M.S. Degree in General Surgery by The Tamilnadu Dr.MGR Medical University, Chennai. This work has not previously formed the basis for the award of a degree or diploma.

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ABSTRACT

Background and Objective:

Gastrointestinal surgeries involving bowel anastomosis is one of the commonly performed surgical procedure in both elective and emergency. Despite recent advances in Gastrointestinal surgery, anastomotic leakage and other complications of intestinal anastomosis are still commonly encountered in ward. A leaking anastomosis almost doubles the hospital stay (increased morbidity) and has been associated with significant mortality. Objective of this study is to predict the anastomotic leak in gastrointestinal surgeries using E-PASS scoring system. Evaluation of Physiological Ability and Surgical Stress (E-PASS) scoring system is designed by Haga et al mainly for predicting the post operative course in GI surgeries. Later E-PASS scoring system is also validated for its use in predicting anastomotic leak in gastro intestinal surgeries

Materials and Methods:

50 patients admitted in General Surgery department in Coimbatore Medical College Hospital undergoing laparotomy involving bowel anastomosis will be studied prospectively during September 2013 to September 2014. Detailed history, clinical examination findings and intra operative details were collected from the patients. Three components of E-PASS scoring system like Preoperative Risk Score, Surgical Stress Score and Comprehensive Stress Score were computed. Patients were followed up in the post operative period and

observed for anastomotic leak and other complications. Outcome of patients were compared with the individual scores of E-PASS scoring system.

Results:

Incidence of anastomotic leaks in the present study is 18%. All the three scores namely Preoperative Risk Score, Surgical Stress Score and Comprehensive Stress Score were found to be significantly associated with the incidence of anastomotic leak with p value<0.01.

Conclusion:

Comprehensive Risk Score of more than 0.9 is significantly associated with anastomotic leaks. In all patients undergoing anastomotic surgeries E-PASS scores should be calculated prior to surgery and if CRS is more than 0.9 alternative options for anastomosis should be considered.

Key Words: Intestinal Anastomosis, Anastomotic Leaks, E-PASS scoring system, Preoperative Risk Score (PRS), Surgical Stress Score (SSS), Comprehensive Risk Score (CRS)

INTRODUCTION

Intestinal anastomosis is a common major surgical procedure done in both elective and emergency settings. The outcome and the prognosis of intestinal anastomosis depends on the parameters related to host, operating technique and nature of the disease.

Intestinal anastomosis is associated with number of complications; the most dreaded being the anastomotic leak. Incidence of the anastomotic leak ranges from 1.5 to 27% depending on type of anastomosis and whether it was done in elective or emergency setting.

Despite recent advances in Gastrointestinal surgery, anastomotic leakage and other complications of intestinal anastomosis are still commonly encountered in ward. A leaking anastomosis almost doubles the hospital stay (increased morbidity) and has been associated with significant mortality.

Coimbatore Medical College Hospital is a tertiary referral centre, where we get a good number of patients undergoing intestinal resection and primary anastomosis. This study is an effort to predict the most dreaded complication of Gastro intestinal surgeries namely the anastomotic leak so that a primary anastomosis of the structures can be avoided by opting for a diversion surgery primarily and later on restoring

the bowel continuity once general condition of the patient improves. This prevents morbidity and mortality of surgeries involving anastomosis of bowel.

Various scoring systems are available for predicting postoperative course of a patient.

According to Haga Y et al (2004) E-PASS scoring system is **more accurate in evaluating elective digestive surgeries** than any other existing system.

Again Haga Y et al (2011) **validated E-PASS Scoring System as a useful tool in predicting anastomotic leaks.**

As mentioned above E-PASS scoring system has been shown to predict post operative course in patients particularly undergoing gastrointestinal surgeries. Application of this scoring system has not been studied in Indian patients. As this scoring system can predict anastomotic leak it will be a very useful tool for intra operative decision making in cases requiring intestinal anastomosis.

Components of E-PASS SCORING SYSTEM:

1. Preoperative Risk Score (PRS)
2. Surgical Stress Score (SSS)
3. Comprehensive Risk Score (CRS)

All the above three scores has been shown to have positive correlation with incidence and grading of complications mainly in abdominal surgeries.

Variables for Preoperative Risk Score:

- Age in years
- Presence or Absence of severe heart disease (NYHA class III or IV)
- Presence or Absence of Pulmonary disease (defined as vital capacity less than 60%)
- Diabetes Mellitus (based on definition of WHO criteria)
- Performance Status Index (described by Japanese cancer society)
- ASA score

Variables for Surgical Stress score:

- Approximate blood loss (ml/kg)
- Operating time (in hours)
- Extent of skin incision. Three scores are given for incion. (0-minor incision, 1-laparotomy, 2-laparotomy with thoracotomy)

Equations

1. Pre operative Risk Score = -0.0686 + 0.00345(F1) + 0.323(F2) + 0.205(F3) + 0.153(F4) + 0.148(F5) + 0.0666(F6)

Factors used to calculate PRS are,

- F1: age,
- F2: presence (1) or absence (0) of severe heart disease,
- F3: presence (1) or absence (0) of severe pulmonary disease,
- F4: presence (1) or absence (0) of diabetes mellitus,
- F5: performance status index (0-4),
- F6: American Society of Anesthesiologists physiological status classification (1-5)

2. Surgical Stress Score = -0.342 + 0.0139(F1) + 0.0392(F2) + 0.352(F3)

- F1: blood loss/ body weight (g/kg),
- F2: operation time (hours)
- F3: extent of skin incision

3. Comprehensive Risk Score = -0.328 + 0.936 (PRS) + 0.976 (SSS)

AIM:

1. To predict the intestinal anastomotic leak in gastro intestinal surgeries involving anastomosis of bowel

OBJECTIVES:

1. To identify risk factors for post operative intestinal anastomotic leak.
2. To study the incidence of anastomotic leak between surgeries involving anastomosis of different segments of bowel
3. To study morbidity and mortality associated with the surgeries involving bowel anastomosis with postoperative anastomotic leak

REVIEW OF LITERATURE

ANATOMY OF GASTRO INTESTINAL TRACT[1]

Gastro intestinal tract extends from oral cavity to rectum. Anatomy of structures involved in surgical anastomosis is explained below.

PERITONEUM AND PERITONEAL CAVITY:

Abdominal cavity and most of the viscera is covered by a thin membrane called peritoneum. It can be divided into,

1. Parietal peritoneum – lines the abdominal cavity
2. Visceral peritoneum – lines most of the viscera

Part of gastro intestinal tract which lies outside the peritoneal cavity (thoracic esophagus and rectum) lacks serosa. Anastomosis involving these structures has more incidence of anastomotic leak[1].

There are numerous folds and reflections of peritoneum which forms omentum and mesenteries.

OMENTUM:

It is made up of peritoneal reflections which extends from the stomach and duodenum to the other viscera. It is further divided into greater omentum and lesser omentum

GREATER OMENTUM:

Embryologically, it is derived from the dorsal mesentery. It is a large peritoneal fold which extends from greater curvature of stomach. It covers coils of small bowel loops and transverse colon like an apron.

LESSER OMENTUM:

Embryologically it is a derivative of ventral mesentery. It extends from the lesser curvature of stomach to the liver. It consists of hepatogastric and hepatoduodenal ligament.

MESENTERIES:

These are peritoneal folds which attach the viscera to the posterior abdominal wall. It provides a conduit for arteries, veins, nerves and lymphatics to reach the viscera.

- Mesentery – suspends small bowel loops
- Transverse mesocolon – suspends transverse colon
- Sigmoid mesocolon – suspends sigmoid colon

All of these are derived from dorsal mesentery.

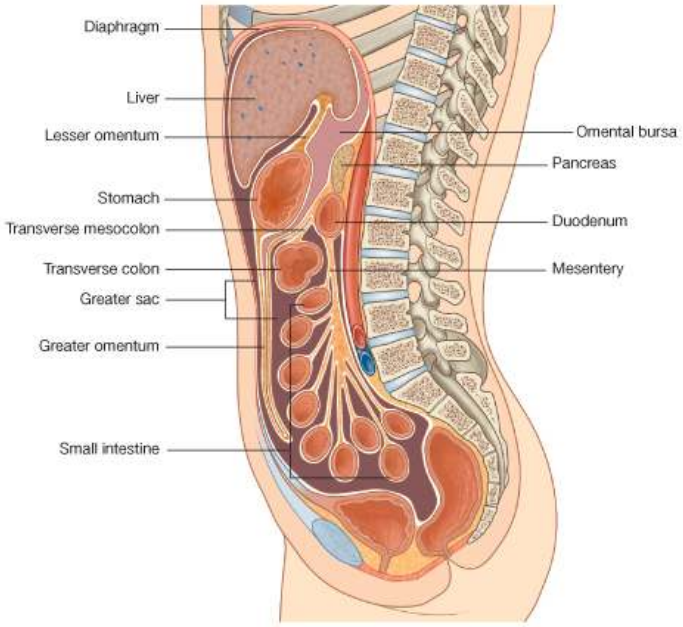


Fig.1: Mid saggital section of abdominal cavity showing peritoneal cavity and reflections of peritoneum

ESOPHAGUS:

Esophagus is a muscular tube which extends through neck, thorax and abdomen. Except small abdominal part, it lacks serosa throughout. It extends from the base of pharynx to abdomen where it joins stomach. It extends from the level of C6 vertebra to T11. Length is around 25centimetres. It is divided into three parts.

Cervical esophagus:

It is around 5-6cms long. It extends from the level of C6 vertebra to T1 vertebra. Cervical part of esophagus commences distal to the cricoid cartilage and extends up to the inlet of thorax which corresponds to the level of sterno-clavicular joint.

Thoracic esophagus:

Thoracic esophagus is the longest part of esophagus with roughly commences at the level of T1 and extends up to the level of T10 or T11. It occupies superior and posterior mediastinum in thorax. It is about 20 centimetres in length.

Abdominal esophagus:

It is the shortest part of esophagus lies inside the abdominal cavity below the esophageal hiatus. It measures up to 2.5 centimetres. Inside the abdominal cavity it is covered by peritoneum in the left side and front.

As mentioned above only abdominal part of esophagus is partly covered with the peritoneum (serosa) and rest of the parts are entirely devoid of serosa. Due to this reason anastomosis involving esophagus has more incidence of leaks. Importance of serosa in aspect of anastomotic wound healing is explained below in pathophysiology.

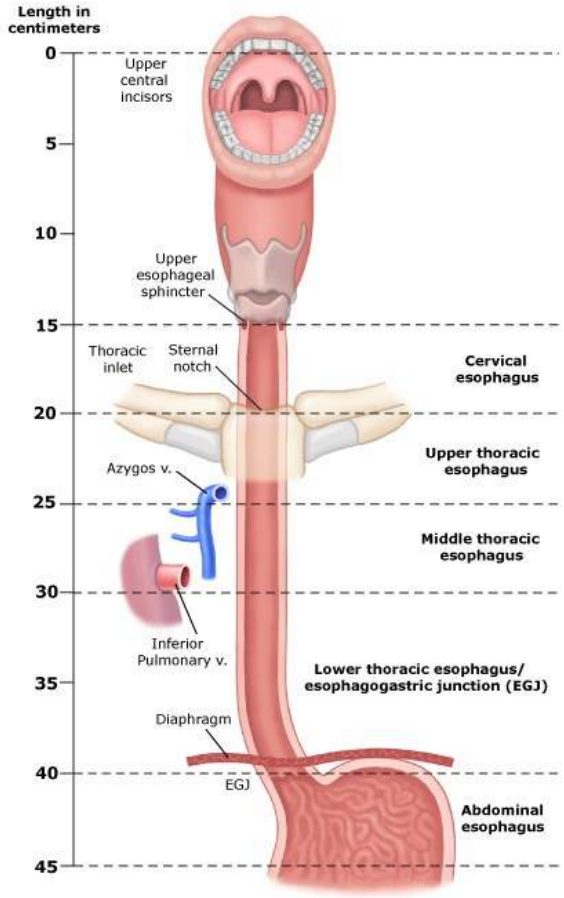


Fig.2: Parts of esophagus and important land marks

Arterial supply of esophagus:

Cervical esophagus is supplied by the branches of inferior thyroid artery. Thoracic esophagus is supplied by the branches from the thoracic aorta. Abdominal esophagus is supplied by ascending branches of left phrenic and left gastric arteries.

Venous drainage:

Cervical esophagus drains into the inferior thyroid vein. Thoracic part drains into the azygos, hemiazygos, intercostals and bronchial veins.

Abdominal part of esophagus drains into the portal venous system through the left gastric vein.

Lymphatic drainage:

- Cervical part – deep cervical nodes
- Thoracic part – posterior mediastinal nodes
- Abdominal part – left gastric nodes

Histology:

Knowledge of histology is important in context of anastomosis. Importance of layers of bowel in anastomosis is explained in relevant sections below.

Histologically, cervical and thoracic part of esophagus lacks serosa which is formed by parietal peritoneum. Innermost layer is squamous epithelium. Submucosa contains many mucus glands whose secretion aids food propulsion. It has thick muscular layer. Muscular layer in proximal part is voluntary while it becomes involuntary distally.

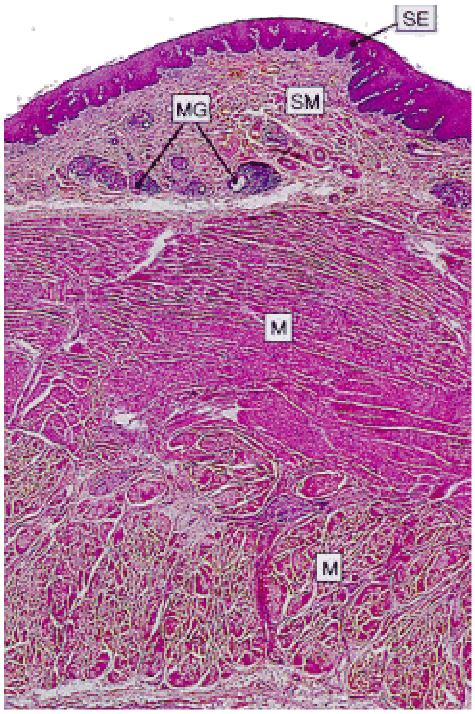


Fig.3: Histology of esophagus

THE STOMACH:

Stomach is a muscular sac of gastro intestinal tract extending from cardiac orifice to pylorus. In surgeons point of view it can be almost divided into two separate surgical units. Proximal Gastric unit consists of proximal stomach, abdominal part of esophagus and esophageal hiatus. Distal Gastric unit consists of distal part of stomach along with the first part of duodenum. Stomach is located at the level of T10 to L3 vertebra. Stomach is divided anatomically into following parts:

1. The **cardia** – It is the most proximal part of stomach. It is physiologically a sphincter which surrounds the esophago – gasric orifice.

2. The **fundus of stomach** – Anatomically it is above the level of cardiac orifice. Almost always contains gas which can be seen in erect abdominal x – ray.

3. The **body of stomach** – It is the region which constitutes largest part of stomach flanked on either side by greater and lesser curvature

4. The **pyloric part** – it is most distal part of stomach consisting of antrum and pyloric orifice

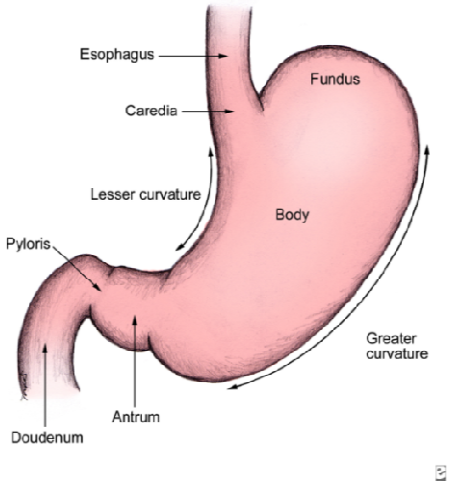


Fig.4: Gross Anatomy of stomach.

Arterial supply:

Three branches of celiac trunk which supplies stomach are left gastric artery, common hepatic artery and splenic artery.

Left gastric artery divides into ascending branch which gives rise to gastric branches and descending branch which gives rise to gastric branches.

Common hepatic artery after giving rise to right gastric and gastro duodenal artery it continues as proper hepatic artery which in turn divides into right and left hepatic artery. Right gastric artery runs along the lesser curvature of stomach. It anastomoses with the left gastric artery along the lesser curvature. Important branches of gastroduodenal artery are Superior pancreaticoduodenal artery which divides into anterior and posterior branches, Retroduodenal artery, Supraduodenal artery and right gastro epiploic artery.

Splenic artery runs posterior to stomach. Morphologically it is identified by its tortuous course. Its branches are posterior gastric branches, short gastric branches and left gastro epiploic branch.

Venous drainage of stomach almost parallels the arteries. Veins from the stomach carry nutrients and ultimately drain into the portal venous system.

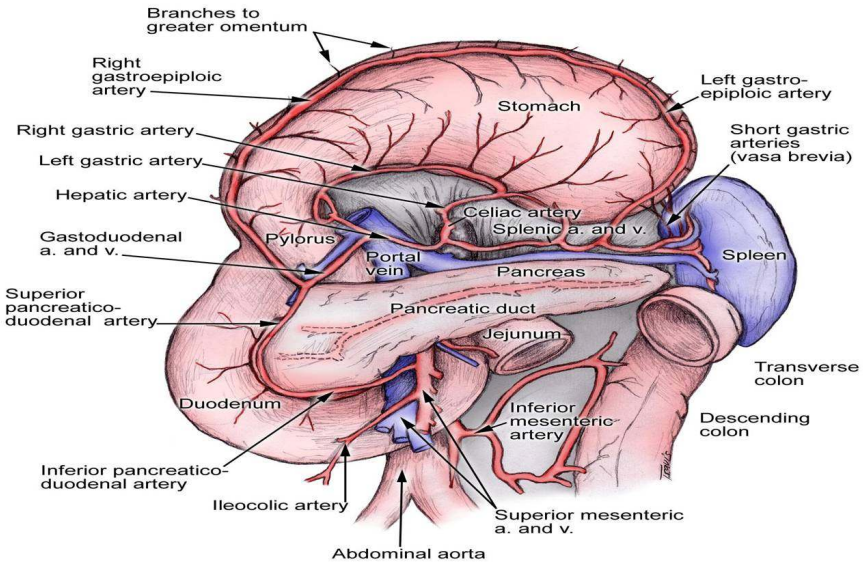


Fig.5: Blood supply of stomach and related structures

Lymphatics of stomach:

Lymphatic drainage of stomach can be explained by dividing stomach into four parts as shown below.

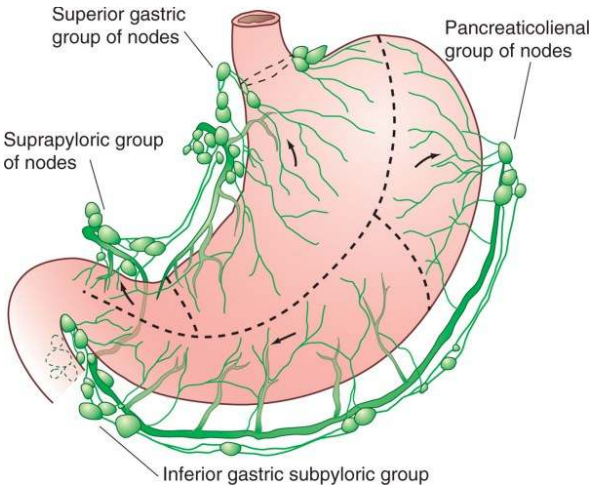


Fig.6: Lymphatic Drainage of Stomach

Stomach can be divided into four parts as shown above and each parts drains into **superior gastric nodes**, **supra pyloric nodes**, **subpyloric nodes** and **pancreaticosplenic nodes**. Lymphatics from all these nodes ultimately drain into **celiac nodes**.

Histology:

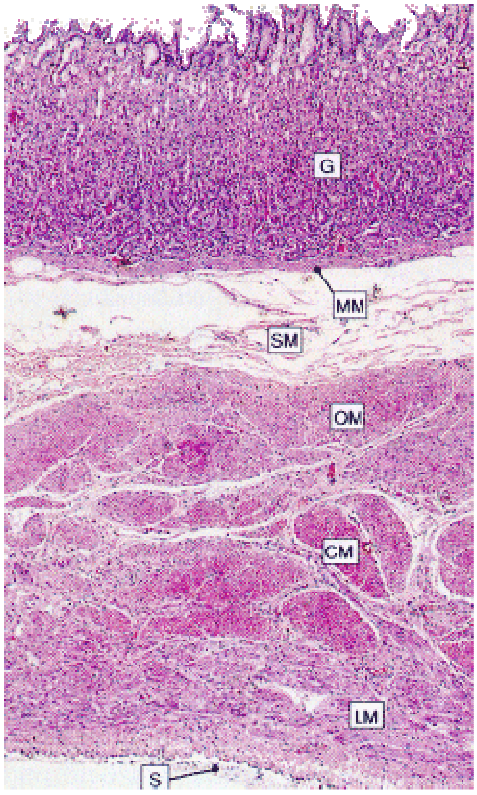


Fig. 7: Histology of Stomach

Gastric mucosa(G) is composed mainly of glandular tissue containing parietal cells chief cells and few endocrine cells of gut. Muscularis mucosa(MM) and submucosa(SM) lies beneath the mucosa.

Stomach has thick muscular layer made up of innermost oblique muscular (OM) layer, middle circular muscle (CM) layer and outer longitudinal muscle (LM) layer. Outermost layer is serosa (S).

SMALL INTESTINE:

Small intestine is a part of gastro intestinal tract which lies distal to stomach and extends upto ileocaecal valve. Obviously it makes maximum part of entire length of intestinal tract. It consists of duodenum, jejunum and ileum.

The duodenum continues into the jejunum at the duodeno-jejunal junction or flexure, which lies to the left of L2 vertebra and is fixed to the retroperitoneum by a suspensory ligament of Treitz. The inferior mesenteric vein (IMV) lies to its left. There are several peritoneal fossae around the flexure, which may be the sites of internal herniation of the small bowel. The rest of the small intestine is a 4-6-m long convoluted tube occupying the center of the abdomen and the pelvis, surrounded on both sides and above by the colon (a part of the large intestine). The ileum continues into the large intestine at the ileocaecal junction.

The small intestine is differentiated from the large intestine by the presence of a mesentery (exceptions being no mesentery in the duodenum, and mesentery in the transverse and sigmoid colons) and the

absence of tenia coli and appendices epiploicae. The demarcation between the jejunum (proximal) and the ileum (distal) is not very clear.

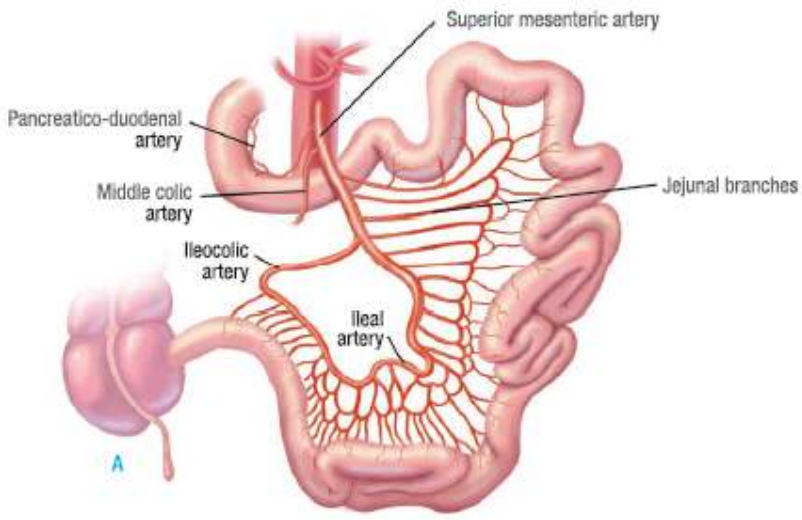


FIG8: Blood Supply of Small Intestine

The Duodenum:

Duodenum commences distal to the pylorus. It is approximately 25centimetres length. It is c-shaped owing to its peculiar relationship with the peritoneal cavity. It is divided into four parts. First part of duodenum lies in supracolic compartment and it is intraperitoneal. Remaining part of the duodenum lies retroperitoneally.

Second part of duodenum is vertically oriented. Bilio-pancreatic duct opens into second part of duodenum in ampulla. The part of duodenum at which ampulla is present is considered as the land mark for distinction into proximal foregut and distal midgut.

Third and fourth part also lies retroperitoneally and distally it projects into the peritoneum as jejunum. The point at which it continues as jejunum is duodeno jejunal flexure. Ligament of trietz extends in between Dj flexure and right crus of diaphragm.

Blood supply mainly comes from anterior superior pancreaticoduodenal artery and posterior superior pancreaticoduodenal artery which are branches of **gastroduodenal artery**. Also from anterior inferior pancreaticoduodenal artery and posterior inferior pancreaticoduodenal artery which are branches of superior **mesenteric artery**.

Venous drainage is mainly into the superior mesenteric vein and portal vein.

Lymphatics drain into the pancreatico duodenal nodes situated along the gastroduodenal and superior mesenteric vessels. Ultimately it drains into the celiac nodes.

The Jejunum and ileum:

Jejunum and ileum constitutes maximum part of small intestine. Length of jejunum and ileum together is about 6 meters approximately. They are supplied by superior mesenteric vessels which forms arcades in the mesentery. The distinction between jejunum and ileum is usually not

well defined. They have few minor differences like vascular arcades are more straight and long in jejunum, circumference of jejunum is little higher than the ileum and submucosa of entire small bowel contains lymphoid tissue but it is abundant in ileum in the form of Peyers patches.

Venous drainage is into the superior mesenteric vein which in turn drains into the portal venous system. Lymphatics of small bowel drain into the mesenteric nodes along the superior mesenteric vessels.

Histology:

Fig.9: Histology of Small Intestine

The peculiarity about the small bowel histology is its mucosal layer is thrown into numerous folds by its plicae and villi. It has enormous surface area for absorption of nutrients. Digestive nutrients from the bowel drains into the portal system and carried to the liver.

LARGE INTESTINE:

Large intestine consists of caecum, ascending colon, transverse colon, descending colon, sigmoid colon and rectum.

Schematically it lies in the periphery while small bowel lies in the centre. Length of entire large bowel varies widely. Usually it is about 1.5 – 2 meters.

Few specific features of large intestine are,

- **Tinea coli** – these are bands of smooth muscles which lies on the surface of the large bowel. Proximally they converge in the base of appendix and distally they fan out to form the longitudinal muscle layer of the rectum.
- Externally sacculations on the surface of the large bowel are called as **haustrations**.

- **Appendices epiploicae** are fat filled pouches of peritoneum found externally on entire length of large bowel. They are typically absent in the rectum.

Hepatic flexure marks the transition between ascending colon and transverse colon. **Splenic flexure** marks the trasistion between the transverse colon and the descending colon.

From the second part of duodenum upto the proximal one third of transverse colon are the derivatives of midgut and distal to that are derivatives of hindgut.

Blood supply of large intestine:

Upto proximal one third of transverse colon, large bowel is supplied by **superior mesenteric artery** and its branches namely ileocolic artery, right colic artery and middle colic artery.

Derivatives of hindgut are supplied by the **inferior mesenteric artery**. Rectum is supplied by **superior rectal artery** which is a branch of inferior mesenteric artery, **middle rectal artery** which is a branch of internal iliac artery and **inferior rectal artery** which is a branch of pudental artery.

Venous and lymphatics follows the arterial supply. Rectum is drained by **superior rectal vein** which drains into inferior mesenteric vein which drains into the portal circulation, **middle rectal vein** which drains into the internal iliac vein and **inferior rectal vein** which drains into the pudental vein.

Griffith point is the watershed area between the superior mesenteric and inferior mesenteric artery. It lies in the splenic flexure.

Sudeck's point is another watershed area between the inferior mesenteric artery and the superior rectal artery. It lies in the recto-sigmoid junction.

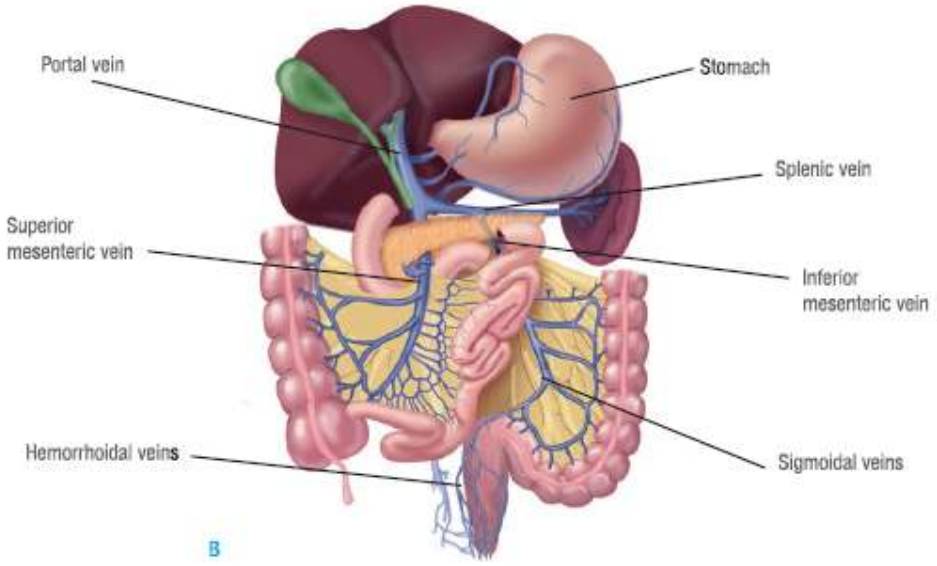


Fig.10: Venous Drainage of GI tract

Histology:

Mucosa of the large bowel is compactly arranged which contains several glands. It is made up of specialised cells for water absorption and it also contains goblet cells which are mucin secreting cells to facilitate the passage of the faeces. Submucosa of large bowel also contains aggregates of lymphoid cells as seen in the small bowel.

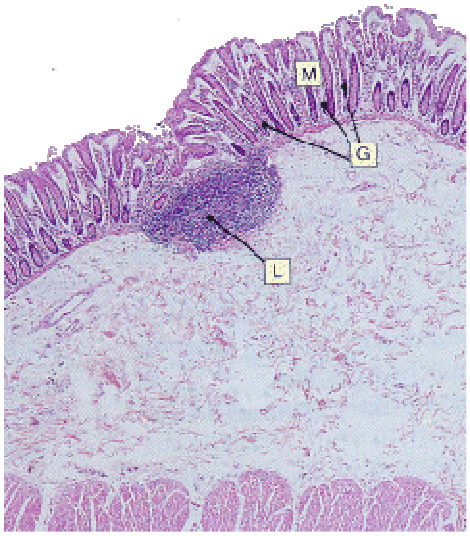


Fig. 11: Histology of Large bowel

HEALING OF INTESTINAL ANASTOMOSIS

Knowledge of gastrointestinal (Gl) surgery has developed gradually over the centuries from a mystical to a scientific level today. During this evolution much emphasis has been placed on suture materials and methods without much understanding of the healing process itself.

Today operations on the gastrointestinal tract are one of the most frequent surgical procedures being done. Our knowledge of gastrointestinal healing has advanced and we have better insight about the healing of the intestinal anastomosis, its pathogenesis and factors affecting the healing of intestinal wounds.

In spite of the better understanding anastomotic leak remains to be one of the frequent complications in the postoperative period and it has significant morbidity and mortality. Because it is difficult to examine the mechanisms of gastrointestinal healing in clinical models except by retrospective analysis, much has been learned by studying animal models, with their accepted limitations.

Healing of intestinal anastomosis can be explained in **three phases**[19]**:**

Early Phase: (0-4 days) – Acute inflammation occurs without any intrinsic cohesion.

Fibroplasia: (3-14 days) – Fibroblastic proliferation occurs along with collagen formation.

Maturation: (>10days) – Remodelling of collagen occurs which contributes to the strength and stability of anastomosis .

If the mucosa is the only injured layer, it heals by rapid epithelial cell proliferation and differentiation in a process called epithelial restitution.

Few animal experiments shows that isolated injury in serosal layer and mucosal layer can heal without any scarring. However, full-thickness injuries require additional repair mechanisms involving non epithelial cell populations and inflammatory processes that provoke fibroblastic responses leading to scar formation.

Similar to cutaneous healing, the first phase of GI healing begins with hemostasis. Initial vasoconstriction is followed by vasodilation and increased vessel permeability (induced by kinins), which allows inflammatory cells (polymorphonuclear leukocytes)to diapedese into the wound.

Diapedesis marks the beginning of the inflammatory phase, which is also characterized by edema formation, mainly in the subepithelial region of the mucosa and the submucosa edema can persist for upto 2 weeks. Neutrophils are the predominant cells during the first 24 hours and macrophages predominate after 48 hours, synthesizing and releasing growth factors that begin and amplify the healing response.

It is postulated that during healing of intestinal wounds there occurs formation of fibrin seal in the serosal side which is very important for the water tightness of the anastomosis. This observation is supported

by the fact that incidence of anastomotic leak is more in the bowel segments outside peritoneal cavity which lacks serosa like esophagus and rectum.

In earlier phases of healing of anastomosis, its integrity depends mainly on the submucosal layer which is important factor for suture holding capacity of bowel. The beginning of the proliferative phase is marked by the presence of granulation tissue in anastomotic wound.

During this phase, collagen undergoes both synthesis (by smooth muscle cells and fibroblasts in the submucosal layer) and lysis (by collagenase activity). Smooth muscle cells contribute more to absolute collagen formation than fibroblasts.

Collagen lysis caused by collagenase activity contributes to low anastomotic strength seen early after the formation of an anastomosis. Thus, the anastomosis is at risk for leakage or dehiscence during the first 3 to 10 days .

Gradually fibroblasts and smooth muscle cells begin to synthesize collagen, which gradually strengthens the anastomosis.

The epithelial layer is fully reconstituted, after 1 to 2 weeks over submucosal granulomatous network consisting of proliferating smooth muscle cells and fibroblasts.

The final phase of healing involves maturation and remodelling of the collagenous network, which results in the anastomosis becoming thinner but stronger.

Figure below shows initial decrease in overall tensile strength of the anastomosis due to predominant activity of collagenase. After few days overall tensile strength increases as fibroblasts predominates and causes increased collagen synthesis[3].

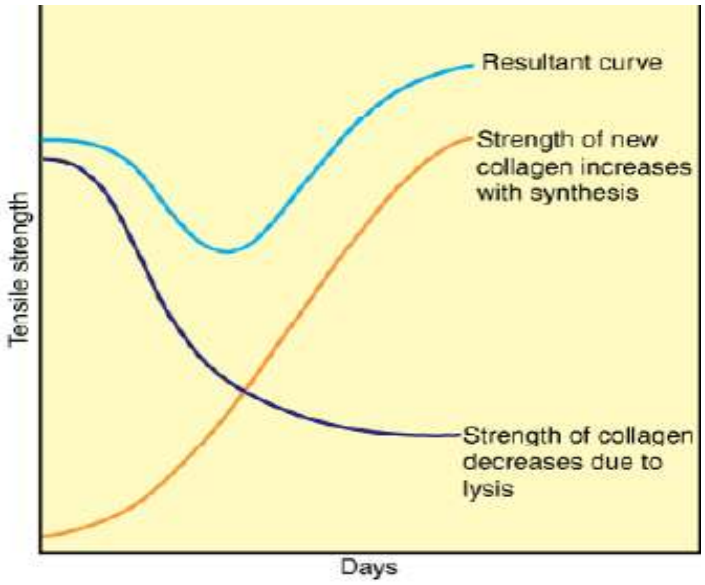


Fig.12: Resultant Tensile strength due to combined action of collagen synthesis and collagen lysis

Most research on wound healing has concentrated on cutaneous models because of the easy availability of this tissue. Caution is therefore essential in translating this data to healing in the GI tract. Few factors which makes wound healing in GI tract unique are multi layered

architecture of the bowel, microorganisms in lumen of bowel, influence of serosa and unique feature of its blood supply which down regulates itself when there is shock.

Comparison of wound healing in skin and GIT[3]:

- pH of the healing environment varies widely in each segment of bowel due to secretions like gastric acid, bile, etc which influences wound healing.
- Different bacterial load in different segments of bowel may alter wound healing process while commensals in skin mostly do not alter healing.
- In gastro intestinal tract, due to absence of pain sensation excessive movement of intra luminal contents across anastomotic segment may disrupt wound healing but in skin pain usually prevents excessive movements.
- It is a proven fact that excessive steroids impair cutaneous wound healing but its influence in the gastro intestinal tract is not well known.
- Collagenase plays very important role in intestinal wound healing while it has no significant role in cutaneous wound healing.
- GI wounds show a very rapid recovery of wound strength than the cutaneous wounds.

- D-penicillamine reduces the collagen cross linking in the cutaneous wounds but it has no effect on the intestinal collagen.

Importance of **collagen** in intestinal wound healing:

Intestinal wound healing depends on quantity and quality of collagen in the submucosal tissue. Submucosa is almost exclusively made of collagen fibrils. Intestine contains collagen I, III and V.

In formation of collagen, an important step which decides its three dimensional structure is formation of hydroxyproline from proline. Hydroxyproline is very important molecule in deciding the three dimensional collagen conformation. In cutaneous wound healing, usually strength of the collagen can be measured indirectly by measuring the level of hydroxyproline.

But no studies have determined weakened anastomotic wound strength in cases with less level of hydroxyproline. Deficiency of vitamin C and excessive steroids are known to impair cutaneous wound healing but its effect on intestinal healing is still debatable.

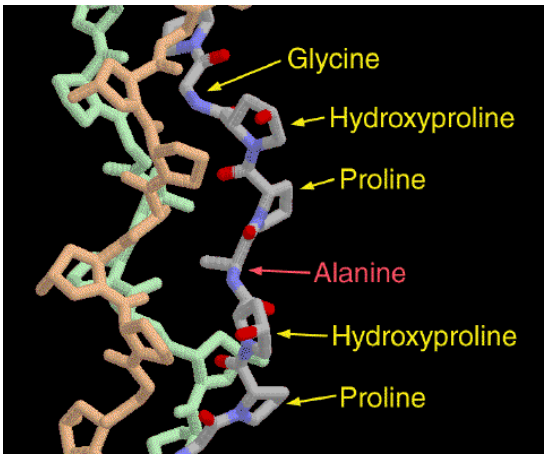


Fig.13: Triple Helix Structure of collagen

FACTORS AFFECTING INTESTINAL WOUND HEALING:

Local factors	Systemic factors
Adequate blood supply	Nutrition of patient
Bowel preparation	Jaundice
Radiation injury	Sepsis
Bacterial contamination	Uremia
Distal obstruction	H5ypovolemia
Healthy tissue edges	Blood transfusion
Absence of anastomotic tension	Drugs – Steroids, NSAIDS, 5FU
Hyperthermia	Immunocompetence

Blood Supply and Oxygenation:

Adequate blood supply is the foremost factor which decides the healing of intestinal anastomosis. During surgery, mobilisation of bowel is an important factor in this aspect. Excessive mobilisation and rough handling of the bowel may damage the vascularity of the bowel and impair wound healing.

In surgeries like closure of transverse colostomy, where it is done through very small incision inadequate surgical mobilisation may lead to increased tension in the suture line and increased linear pressure along the suture line may impair healing of anastomosis. The effect of tension on local microcirculation is tolerated in the colon.

Most patients who needs resection and anastomosis in emergency situations presents to surgeon in casuality with hypovolemic shock. In those patients with shock, gut down regulates its own blood supply to increase perfusion to vital organs. In such situations anastomosis without proper resuscitation, gut remains under perfused.

Anastomosis done in such situations may not heal since oxygen is very important for conversion of proline to hydroxyproline which is a critical step in stabilisation and three dimensional conformation of collagen molecule. Decreased collagen synthesis in hypoxic situations obviously leads to anastomotic leak.

The best method of monitoring GI tissue oxygenation is the measurement of intramural pH22. Alternatively laser doppler flowmetry can also predict impaired anastomotic healing.

Blood Transfusion:

Blood transfusion suppresses the immune response and result in enhanced tumor growth and increased rate of tumor recurrence. Few studies have also demonstrated increased incidence of infections in

patients having multiple blood transfusions. They also impair the healing in colonic anastomosis and increase the incidence of intraperitoneal sepsis. It is not clear whether the deleterious effect of blood transfusion on healing is due to an increase in peritoneal sepsis or due to direct impairment of the healing process.

Lymphocytes play a significant regulatory role in cutaneous wound healing. Multiple blood transfusions causes disturbances in normal formation of lymphocytes. It affects the interaction within lymphocytes during inflammation and wound healing by reducing the production of lymphocyte Interleukin(IL)-2. This is the possible pathway through which blood transfusion compromises intestinal healing.

Radiation Therapy

Resection and anastomosis surgeries are now increasingly performed in patients with GI malignancies aiming at radical cure. Radiotherapy reduces the viability of tissues in GI tract and also reduces the healing capacity. Possibly these effects of radiation are due to **endarteritis obliterans** which leads to local ischemia or fibrosis.

It is studied that these effects of radiation are seen in the gut for as long as 4 months. Despite the method of anastomosis, whether it is hand sewn or stapled, radiation therapy causes significant anastomotic leaks in postoperative period.

Sepsis

Sepsis is an important factor which interferes anastomotic wound healing particularly in emergency cases. It is already explained in pathophysiology that during initial 10 days, overall tensile strength of the anastomotic wound becomes less due to the predominance of collagenolysis over collagen synthesis. Collagenase activity is mainly due to presence of granulocytes.

In patients with peritoneal contamination, fecal soiling and tissue necrosis, presence of granulocytes is increased. Less collagenolysis occurs in the ileum than in the colon during the first 24 hours of healing, and preoperative levels of collagen are restored more rapidly in the ileum. These conditions may account for the lower incidence of dehiscence in ileal anastomosis. Furthermore granulocytes nearly disappear from ileal anastomoses by day 7, but not from colonic anastomosis.

Mechanical Bowel Preparation:

For years it has been believed that efficient mechanical bowel preparation and fecal unloading are among the most important factors in preventing complications of colorectal surgery . In many hospitals bowel preparation is commonly done by giving low residue diet for the patient for few days before surgery and osmotic laxatives are also commonly

used for catarrhesis. This dogma was justified by evidence that feaces could disrupt the anastomosis.

However, patients operated upon without bowel preparation rarely experience mechanical disruption of the anastomosis. Other works suggesting that the bursting pressure of colonic anastomoses in unprepared bowel is decreased may not be relevant because the intraluminal pressure is significantly lowered in the first postoperative week and is therefore not a primary concern in anastomotic dehiscence.

Other factors that favour avoiding mechanical bowel preparation are the avoidance by the patient due to excessive diarrhea and electrolyte disturbance with fluid imbalance in the hours prior to surgery. Many clinical studies done in this context demonstrate no advantage of bowel preparation over unprepared bowel in terms of patient outcome[15]. They state that omitting bowel preparation avoids the "semi prepared" colon scenario with bowel full of fluid feces, a condition that is difficult to deal with intraoperatively and may lead to the leakage and peritoneal contamination postoperatively. Further studies have to be done on this topic to resolve the need for bowel preparation.

BOWEL REST

Low residue diet

Low residue diet is usually advice in many centres for patients in preoperative period with an idea that use of low residue diet may reduce

the fecal content and thus reducing the intra luminal pressure. But studies have not demonstrated any advantage of using low residue diet. This is because it may reduce both collagen synthesis and collagenolysis. Thus it offers no added advantage in terms of wound healing. Furthermore, it has been shown that long term postoperative low residue diet may actually reduce collagen content and impair wound healing. It due to the fact that intra luminal pressure acts as a stimulus for more collagen synthesis.

Diabetes

Association of diabetes with the anastomotic leak is doubtful. Collagen content and synthetic capacity in the anastomosis were unaffected by the diabetic state in a rat model. Although a marked decrease in the bursting pressure occurs in the third postoperative day in a diabetic individual, it does not persist beyond the seventh day.

It is postulated that diabetes may indirectly contribute to impaired wound healing which may be due to increased micro abscess formation at the anastomotic site. Pancreatic islet transplantation or insulin treatment in diabetic patients is observed to reduce the impairment on wound healing process. Impaired anastomotic healing is also seen in patients with other metabolic conditions like severe jaundice and uremia. All of the above metabolic disorders are accompanied by malnutrition, which may underlie some of the observed facts.

Medications and Drugs

Nonsteroidal Anti-Inflammatory Drugs (NSAIDS)

NSAIDS are known to promote healing in anastomotic sites by both reducing the lysis of collagen and increasing its production. The antiprostaglandin effect of NSAIDs may be responsible for these findings and also explains the selective nature of this effect, which is observed only with drugs having anti-prostaglandin E2 activity. Unfortunately the adverse side effect of NSAIDs prevents the use of these drugs in human trials. Conversely, Misoprostol, a synthetic prostaglandin El, increases the collagen content of anastomoses, albeit at day 14.

5-Fluorouracil (5-FU)

Adjuvant chemotherapy has beneficial effects on colorectal cancer when administered after surgical resection. However, like most of the available chemotherapy drugs it has an immunosuppressive effect that may be detrimental to the healing process. Collagen synthesis is reduced in the presence of 5FU, but waiting 3 days after the surgery before commencing drug administration diminishes this effect.

5-FU decreases the number of leukocytes in the blood, but a study of myeloperoxidase activity at the anastomosis reveals no actual decrease in wound site neutrophil concentration. Adjuvant chemotherapy in the form of Levamisole or a combination of levamisole and 5-FU also compromises the healing of both small and large bowel anastomoses.

However a regimen of 5- FU and Leucovorin did not alter the colonic healing capacity[25].

Growth Factors

Transforming Growth factors (TGF) alpha and beta produced by platelets are known to promote anastomotic healing in many ways. It attracts fibroblasts to the anastomotic sites, stimulates the production of collagen and down regulates collagenase activity in the gut. It is also shown to reverse the inhibitory effect of steroids in a pig model of intestinal healing. Recombinant growth hormone is also found to increase the anastomotic wound healing by increasing protein synthesis.

Local or Enteric Nutrition

Short-chain fatty acids (SCFA) are produced by fermentation of the dietary fibre. This occurs in the colon, where the natural flora produces acetate, propionate, and butyrate. The SCFA stimulate the proliferation of epithelial cells and provide them with an energy source. The use of antibiotics, mechanical preparations, and low-residue diets reduce the bacterial content of the gut and therefore the production of SCFA and may lead to impaired mucosal healing. Pectin, a non-cellulose dietary fiber when fermented in the gut produces SCFA and has been shown to enhance the healing in the colon. Direct intraluminal infusion of SFCA also found to enhance Colonic anastomotic healing.

Systemic or Parenteral Nutrition

Malnutrition in any form affects the process of wound healing probably by reducing the protein synthesis[26]. Controversy still exists over the use of parenteral nutrition and full enteral nutrition in the surgical patients. There is also wide variety of thoughts in timing of commencing these kinds of feeding. In animal studies, beneficial effects were noted in colon anastomotic healing after the introduction of early postoperative total parenteral nutrition (TPN). Whereas immediate introduction of full enteral nutrition increases colon anastomotic bursting strength. In clinical situations, the routine use of preoperative TPN is not justified in unselected patients. Most of the patients undergoing elective GI surgery do not need these nutritional interventions.

In addition use of perioperative TPN does not decrease surgical complications or improve patient outcome.TPN is much more costly than perioperative enteral nutrition. Patients who are chronically debilitated from disease, surgical complications or sepsis and cannot maintain an adequate caloric intake require nutritional support to withstand the catabolic insult of surgical trauma. Enteral nutrition is usually preferred than TPN because entral nutrition prevents damage to mucosa and reduces translocation of micro organisms.

Ascorbic acid is essential to the process of GI healing through its role in procollagen secretion from the intestinal smooth muscle[27].

Glutamine is a possible enhancer of Gl healing because it is one of primary respiratory fuels of the GI tract.

Age

The incidence of anastomotic complications increases with age. It may not be due to the direct effects of ageing in the anastomotic healing. It is due to the presence of increased incidence of adverse comorbid diseases which may decrease the wound healing capacity by reducing the synthesis of collagen.

INTESTINAL ANASTOMOSIS – SURGICAL ASPECTS

Anastomosis is a surgical procedure to establish continuity between two portions of intestine. It can be defined as communication of intestinal lumen with its region or with another part of intestine[1]. It is one of the commonly performed procedures in emergency setting. In elective setting it is performed for resection of benign or malignant lesions of bowel.

HISTORICAL BACKGROUND:

The term 'ANASTOMOSIS' was coined by **Erasistratus** (304BC – 250BC), who is considered as the father of physiology. It is also found in the literature of **Galen** (130AD – 200AD).

Earliest surgical work of intestinal anastomosis is done by **Aurelius celsus** in early 1st century AD when he performed suturing of protruding intestines through the abdomen injuries. He has described how to recognise whether the bowel is viable and how to suture bowel with surgical hooks which were available at that period.

Shusrutha – remarkable ancient Indian surgeon sutured bowel with heads of black ants (Lasius Niger) in cases of intestinal perforation (which he refers as chidrodara in sushrutha samhitha[14]). Surprisingly he was able to apply an absorbable biological suture like ant heads much before the introduction of sutures like catgut.

In 1747, **Duverger** resected a segment of small bowel with gangrene and was able to anastomose it over a piece of an animal trachea and he has written that it was expelled in 21st POD and patient convalesced. There were numerous canine experiments on managing the intestinal wounds but for many centuries there were no remarkable improvement in suturing bowel in human.

In 1812, an English surgeon **Benjamin Traves** explained that bowel injuries heals due to adhesive inflammation in the outer peritoneal layer – serosa. Based on this finding, **Antonie Lembert**, a French surgeon demonstrated a new method of suturing with serosal inversion in 1826. This method of suturing still bears his name as lembert sutures which is mainly used in constructing second layer of intestinal anastomosis. Originally lembert's suture was demonstrated in dogs which is latter applied in human surgeries.

In later part of 19th century Listerine principles of antisepsis in surgery and introduction of General anaesthesia led to many laparotomies. Till then intestinal surgeries were mostly limited to injured bowel protruding through the stab wound. In 1896, **William Steward Halsted** conducted few remarkable surgical experiments and he explained the importance of including submucosa in the anastomosis which is the richest source of collagen in intestinal wall thus enhancing the integrity of anastomosis.

In the same period **John B. Murphy** introduced a new method of anastomosis which is popularly called as Murphy's button. It had two metal rings inserted into two ends of bowel which is sutured with catgut and a spring coil which keeps them in position. Later it is expelled through rectum. It disappeared from surgical practice because of few

reported complications at that time. But it formed a basis for Biofragmentable Absorbable Rings which are recently under study with some promising results.

In 1893, **Nicholas Senn**, a surgeon from Chicago demonstrated two layered interrupted suturing technique using fine aseptic silk. At the beginning of 20th century, in 1903 **Gregory Connell** described an excellent technique in which he applied a single layer suture with all knots lying intra luminally. In 1900, **E Theodor Kocher**, a Nobel laureate advocated all coats suture using two layer silk and catgut.

Indications for intestinal anastomosis:

It can be broadly classified into two categories.

1. Restoration of intestinal continuity following resection of diseased intestinal segment.
2. Bypass of diseased unresectable bowel segment.

Restoration of intestinal continuity following resection of diseased intestinal segment:

- Gangrene of intestinal segment due to vascular compromise resulting from mesenteric vascular occlusion, prolonged intestinal obstruction or volvulus.
- Malignant tumors of bowel.
- Benign causes such as intestinal polyps, intussusceptions.
- Infections like tuberculosis causing complications such as stricture or perforation.
- Traumatic bowel injuries.
- Large peptic ulcer perforation not amenable to primary closure
- Radiation enteritis leading to complications such as bleeding, stricture or perforation.
- Inflammatory bowel diseases – crohn's disease or ulcerative colitis when refractory to medical treatment and leading to complications such as perforation, bleeding, toxic megacolon, dysplasia and carcinoma.
- Diseases leading to chronic constipation such as Hirschsprung disease or idiopathic slow transit constipation for which subtotal colectomy with colo-rectal anastomosis is done when disease is refractory to medical therapy.

Bypass of diseased unresectable segment:

- Locally advanced unresectable malignant diseased causing luminal obstruction – like pyloric carcinoma causing gastric outlet obstruction is treated with gastro jejunostomy and unresectable obstructing tumours of caecum or ascending colon treated with ileo-transverse anastomosis.
- Poor general condition of patient which prevents major resection procedures particularly in emergency setting.

Relative **contra indications** for resection and anastomosis:

There are no absolute contraindications for anastomosis. Following are some relative contra-indications in which surgeon can decide about deferring a major procedure.

- Severe sepsis
- An unhealthy bowel condition which precludes primary anastomosis
- Poor nutritional status – eg: severe hypoalbuminemia
- Faecal contamination or frank peritonitis
- Disseminated malignancy with multiple serosal and peritoneal deposits
- When viability of bowel segments is in doubt

SUTURE MATERIALS commonly used in our hospital:

1. **ABSORBABLE:**
    a. Monofilament: Catgut plain, chromic catgut, PDS-polydioxanone
    b. Poly filament: polyglactin-Vicryl
2. **NON-ABSORBABLE**:
    a. Monofilament: Polypropelene, Nylon
    b. Poly filament: Silk, Linen
    c. Metallic: Stainless Steel

Poly filament sutures like silk are easy to handle and have good knot holding property but their braided nature can provide nidus for organisms to grow and cause infections. Monofilament sutures are difficult to handle but they have excellent tensile strength and lesser incidence of infection than polyfilament sutures.

Suture materials[2] commonly used in bowel anastomosis and few salient feature about them are given below:

Catgut:

It is either plain or tanned with chromium salts. It is derived from submucosa of sheep or cattle intestine. Tensile strength is lost within 7-10days. It gets absorbed by phagocytosis and enzymatic degradation.

Chromic catgut has higher tensile strength which is lost within 21-28 days. It takes 90days for complete resorption. Catgut usually evokes high tissue reaction.

Vicryl:

Polyglactin sutures are braided, polyfilamentous absorbable sutures. It remains as most commonly used material for intestinal anastomosis particularly for the inner layer. It undergoes absorption by hydrolysis. Tensile strength is better than catgut and it evokes only minimal tissue reaction.

Silk:

It is a natural, multifilament and braided material. It is a natural protein derived from silkworm. It evokes high tissue response and absorbed slowly over 1-2years. But its excellent knot holding capacity and easy handling makes it reliable in difficult suturing situations like ligating vessel in deep cavities. In gastro intestinal anastomosis it is used in constructing second layer of anastomosis.

Techniques of anastomosis[4,5]**:**

Types of stitches in intestinal anastomosis:

1. **Traditional all-coats stitch:**

Full thickness of the intestinal wall is taken into the suture.

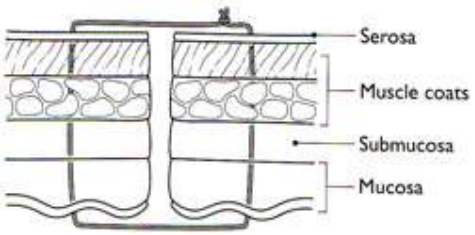


Fig.14: All coats stitch of bowel wall

2**. Sero-muscular stitch:**

This includes serosa and muscle coats and a part of submucosa. It is used in suturing the outer layer of anastomosis. This type of suturing is also called as Lembert's suture.

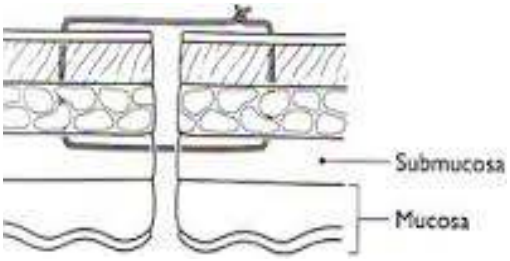


Fig.15: Lembert's suture

3.Extra-mucosal stitch:

This type of stitch is recently gaining popularity. In this method all layers are included except the inner mucosal layer.

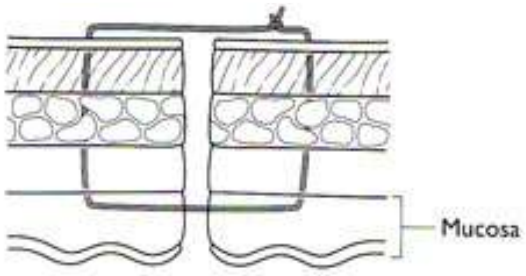


Fig.16: Extra-mucosal stitch

Apart from these basic types of stitches there are few types of suturing demonstrated by specific surgeons. They are as follows

Gambee stitch:

Surface area of mucosa is much more greater than the serosa. So in an injured bowel mucosa tends to protrude outside which prevents proper apposition of serosa. Gambee stitch is typed of inverting mattress suture which inverts bowel wall. It is commonly employed in single later interrupted suturing.

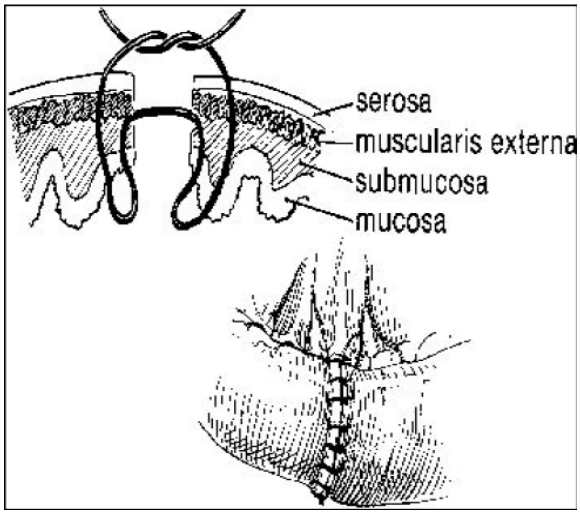


Fig.17: Gambee stitch

Halsted stitch:

This type of stitch is popularised by Halsted. He explained importance of incorporating submucosa in the suturing and he also believed that avoiding mucosa in stich is necessary for proper apposition.

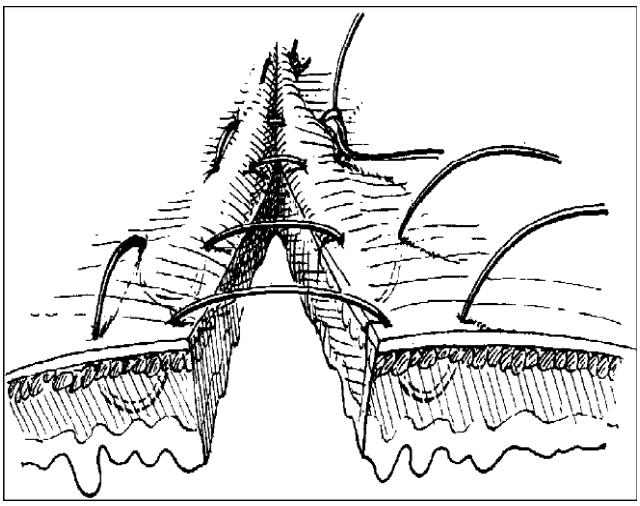


Fig.18: Halsted stitch

Connell's stitch:

This is a type of continuous running stitch which incorporates all layers and it is commonly employed in suturing anterior part of inner layer.

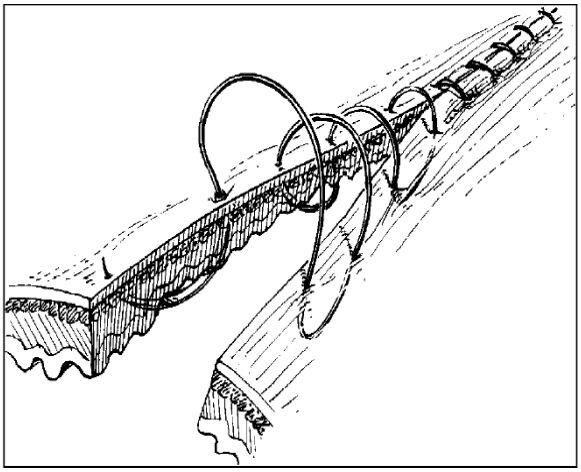


Fig.19: Connell's suturing

Hand Suturing Techniques:

Traditionally, bowel is united in two layers, using catgut or another absorbable suture material for the inner all-coats layers and an outer stitch (called after its inventor Lembert) to join the seromuscular layers. In certain sites only a one layered anastomosis can be achieved e.g. Colorectal, biliary enteric and oesophagojejunostomy.

Surgeons have long disputed the best suture material, the best type of stitch and the best methods of fashioning a suture line. Many surgeons believe that these technical points are less important than the principle to achieve accurate and tension free coaptation of two healthy mucosal surfaces. Nevertheless each surgeon develops his own variations of technique, which he believes to be the most appropriate.

Surgical trainees are often uncertain whether to use continuous or interrupted sutures in a given situation. A continuous (running) stitch is undoubtedly quicker and it achieves good hemostasis. It is therefore appropriate for straightforward gastric, enteric and colonic anastomoses. Care must be taken to maintain the tension on the previous stitch when inserting and pulling through its successor. The assistant should keep the suture material taut until the surgeon is ready to pull the next stitch.

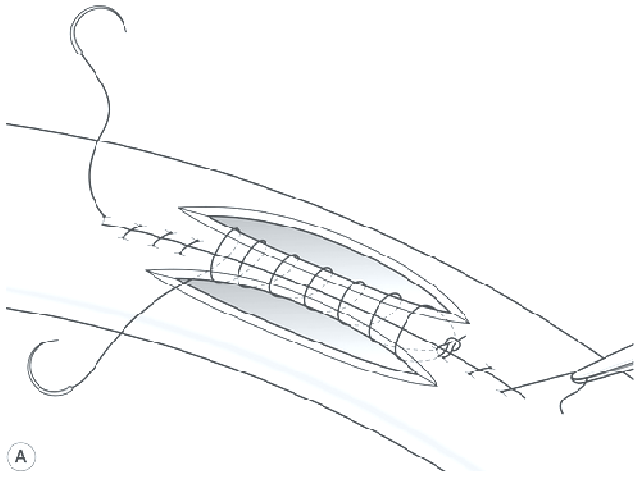


Fig.20: Continuous running sutures in inner layer

Interrupted sutures allow slightly greater precision and may be more convenient than a continuous stitch when there is marked disparity in the size of the bowel ends to be united or the anastomoses is technically difficult. In inaccessible situations it may be wise to insert the entire posterior row of interrupted sutures before tying any individual stitch.

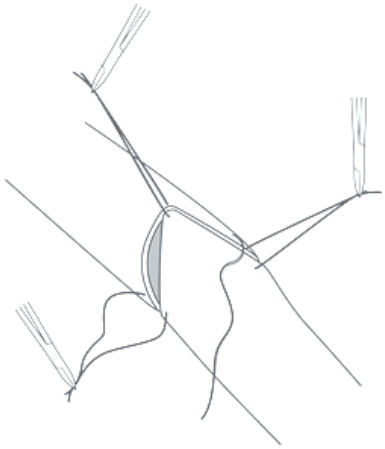


Fig.21: Interrupted end to end suturing

Many surgeons routinely use two layers of continuous catgut sutures for gastric and intestinal anastomoses. If impaired healing is anticipated, e.g. in crohns disease, anastomosis can be done in two layers with absorbable suture material like catgut for inner layer applied in continuous manner and outer layer with surgical silk. This two layered technique would provide additional security.

Whichever suture material or type of suture is used it is imperative to achieve the correct degree of tension when pulling through and tying the stitch. Insert each stitch separately and invert the bowel edges as the suture is tightened. Once the bowel edges are inverted it prevents the suture material from slipping by getting your assistant to follow up. The objective is a snug, watertight anastomosis. Excessive tension increases strangulation of the bowel incorporated in the stitch and perhaps causing subsequent leakage.

Care must be taken not to place the sutures so close to the edge of the bowel that they may tear out or so deep that they turn into an enormous cuff of tissue and narrow the lumen of the bowel; usually 3-5mm is the correct depth of the bite. All layers of the bowel wall must be included in the sutures. The muscularis tends to retract and may escape being sutured especially posteriorly.

The seromuscular stitch unites the adjacent bowel walls outside the allcoats stitch. Sometimes the posterior seromuscular layer is inserted before opening the bowel, e.g. in side-to-side anastomoses. After the all-coats stitch has been inserted, the seromuscular sutures are carried round the ends of the anastomosis and across the front wall, ultimately encircling the anastomoses so that the all-coats stitches can no longer be seen. For end-to-end anastomoses in small and large intestine it may be simple to complete the all coats before placing any Lembert's suture.

Thereafter, the seromuscular layer can be inserted all the way by rotating the bowel.

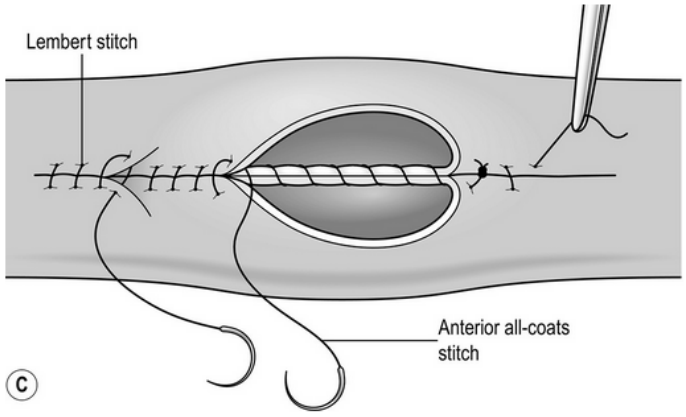


Fig.22: Traditional two layered closure with inner all coats stitch and outer lembert's stitch

The all-coats stitch is accepted as the paramount stitch for holding bowel edges, since it catches the strong submucosa. There are many ways of inserting this all coats stitch but the continuous over-and-over suture, continuous over-and-over plus Connell stitch and Interrupted suture are by far the most commonly used in clinical practice.

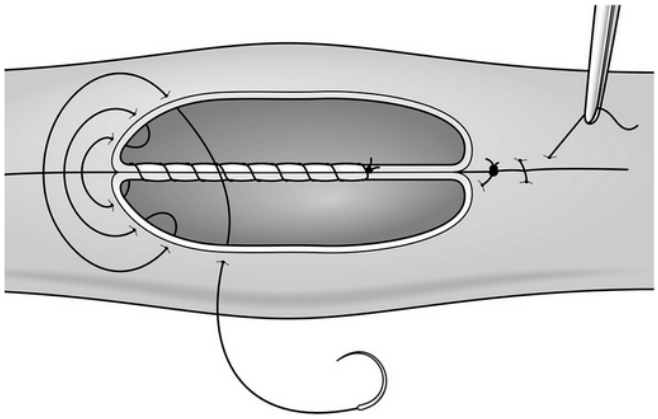


Fig.23: Connell's suture – in anterior part of inner layer

Gastro-intestinal stapling devices[16]:

Introduction of stapling devices in gastro intestinal surgeries dates back to 17th century when **Henroz**, a Belgium surgeon used a mechanical device in suturing dog intestine in vitro. In 1908, **Humer Hultl** introduced an intestinal stapling device for using in human surgeries. It was heavy and took few hours for assembling the device. So it did not gain popularity due to difficulty in practical handling.

Fig.24: Hultl's stapler

In 1950's after World War II USSR recognised the importance of engineering new surgical devices since there was acute shortage of surgeons. Surgical Institute for Surgical Stapling Devices and Instruments was formed for this purpose in USSR. They developed suturing devices which are the precursors of modern gadgets. They invented double linear row of staplers and cutting between two rows.

Dr. Mark Ravitch, an American surgeon studied these Russian instruments and then deviced instruments with disposable catridges, staples in double staggered rows, circular staplers and staplers with different length. Thus era of modern staplers started from that time.

Few commonly used stapling devices are explained below:

Linear TA staplers:

These staplers are used in thoracic and abdominal surgeries (TA) staplers. They produce everting anastomosis by applying double line staggered staples. They are used particularly for cutting lung parenchyma in pulomonary lobectomy, distal gastrectomy and many other GI surgeries.

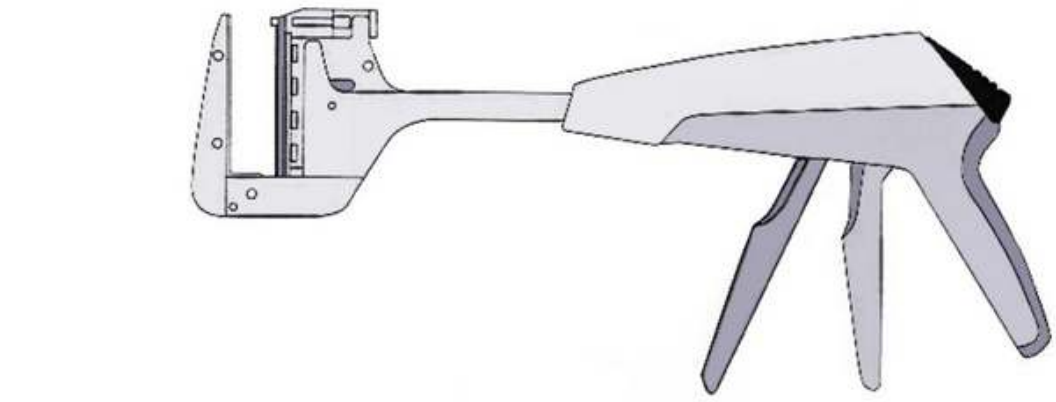


Fig.25: Linear non-cutting stapler

Linear cutting GIA staplers:

These staplers are now commonly used in nearly all anastomosis of Gastro intestinal tract starting from esophagus to rectum in wide variety of situations (GIA – stands for Gastro Intestinal Anastomosis). They deliver double row of staggered staples and cut in between. Welter popularised it use in gastrojejunostomy during billroth II surgery and then resecting stomach with linear TA. Ravitch applied similar technique in small and large bowel resection, where he performed distal anastomosis with linear cutting GIA staplers and then resecting the specimen with linear TA stapler.

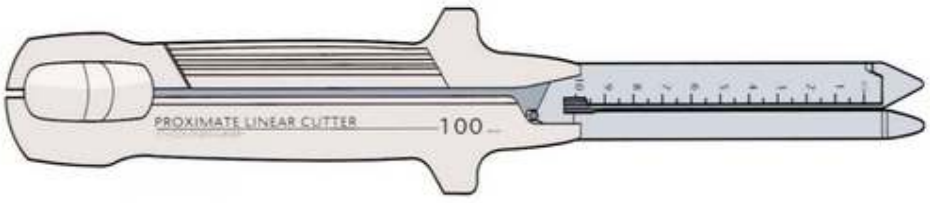


Fig.26: Linear cutter GIA stapler

Circular EEA staplers:

These staplers used to construct End to End anastomosis (EEA). They are also available with curved shafts which can be used in areas of difficult access like colorectal anastomosis. All mentioned devices above are now being used in laproscopic surgeries also.

Fig.27: Circular stapler used for End to End anastomosis

Physiology of GI stapling:

GI staples are made from much finer materials than sutures. Tissue vialbility beyond the line of stapling is due this finer nature of staples and B-shaped configuration once they are fired. It allows blood vessels to pass through the stapled areas and ensuring the bowel viability[17].

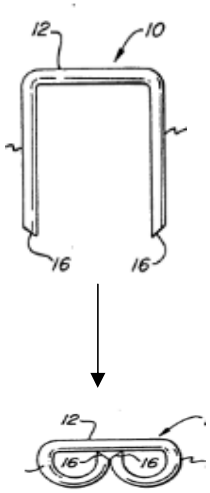


Fig.28: B – configuration of staples after firing stapler

As these staplers are designed to ensure bowel viability, they are not totally hemostatic particularly in organs with high vascularity like stomach. So hemostasis must be ensured in all cases after stapling. Mechanical failure are rare but they should be kept in mind. Always check whether all sutures are applied in B-configuration. Mechanical failure is mostly due to abuse of the stapling devices.

Linear tension in anastomotic line is important particularly in esophagus and colo rectal anastomosis. Since stapler materials are finer than the conventional sutures they tend to cut through the tissues more easily than the suture materials. Closure of transverse colostomy is another situation where linear tension in anastomotic line plays a vital role since surgery is usually done through small incisions without assessing adhesions of the both segments.

Stapling techniques:

Commonly done techniques with intestinal staplers are explained below.

1. Primary closure of transacted bowel ends are commonly done using linear TA staplers or GIA staplers which applies two rows of staggered sutures and cut between the two

2. End to end anastomosis is done using circular EEA staplers as shown below. It is particularly useful in colorectal anastomosis.

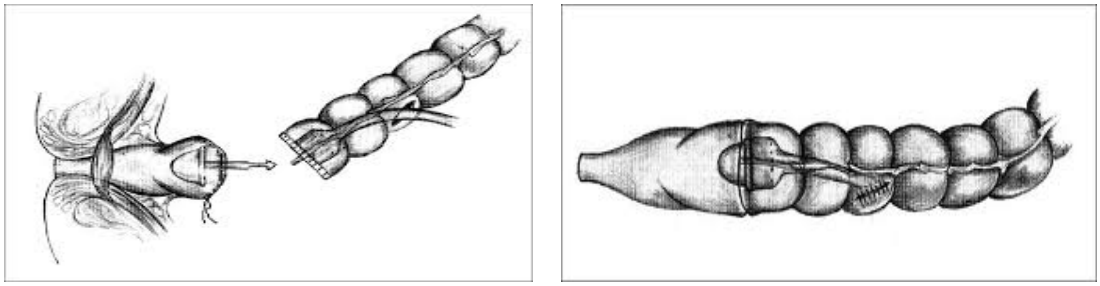


Fig.29: End to end anastomosis using Circular EEA staplers.

3. Linear GIA cutting staplers are used in creating side to side anastomosis in Gastrojejunostomy . It is also used to created functional end to end anastomosis as in ileo-transverse anastomosis.

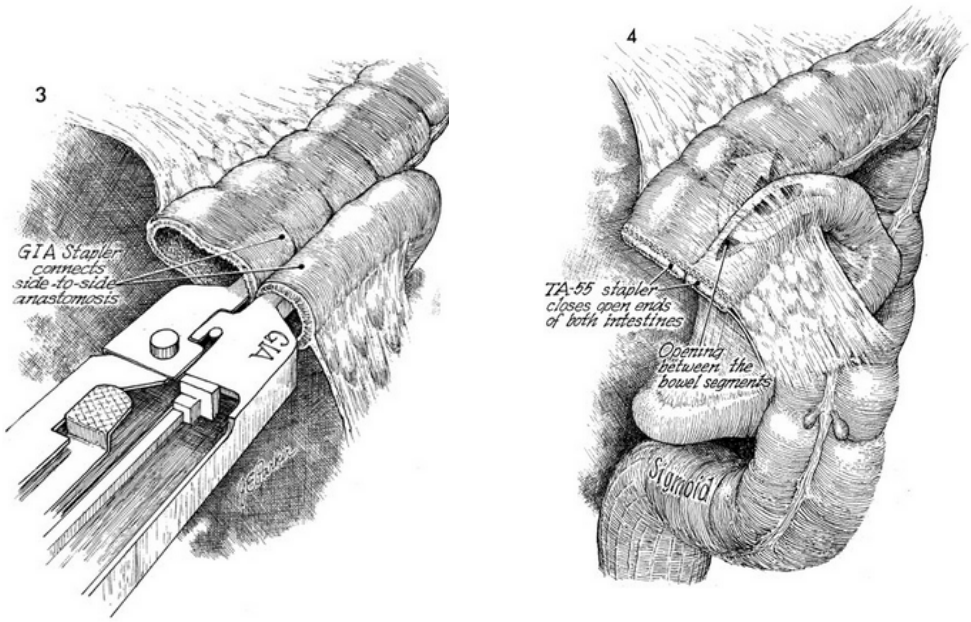


Fig.30: Functional end to end anastomosis

Though these stapling methods are precise, rapid and user friendly, no advantage has been proved in situations like peritonitis, ascites and multiple peritoneal metastatic deposits. Recent meta analysis suggests that use of stapler is as good as hand sewn techniques in terms of patient outcome. Yet cost is the determining factor which limits the usage of these gadgets in developing countries.

E-PASS SCORING SYSTEM

Haga et al devised Estimation of physiological ability and surgical stress (E-PASS) scoring system and validated it for risk stratification of patients undergoing elective general gastrointestinal surgery

According to Haga Y et al (2004) E-PASS scoring system is **more accurate in evaluating elective digestive surgeries** than any other existing system[7].

Again Haga Y et al (2011) validated E-PASS scoring system as **useful tool in predicting anastomotic leak and its prognosis[8].**

Components of E-PASS SCORING SYSTEM:

4. Preoperative Risk Score (PRS)
5. Surgical Stress Score (SSS)
6. Comprehensive Risk Score (CRS)

All the above three scores have positive correlation with incidence and grading of complications mainly in abdominal surgeries.

Variables for Preoperative Risk Score:

- Age in years
- Presence or Absence of severe heart disease (NYHA class III or IV)
- Presence or Absence of Pulmonary disease (defined as vital capacity less than 60%)
- Diabetes Mellitus (based on definition of WHO criteria)
- Performance Status Index (described by Japanese cancer society)
- ASA score

Variables for Surgical Stress score:

- Approximate blood loss (ml/kg)
- Operating time (in hours)
- Extent of skin incision. Three scores are given for incion. 0-minor incision, 1-laparotomy, 2-laparotomy with thoracotomy)

Equations

1. Pre operative Risk Score = -0.0686 + 0.00345(F1) + 0.323(F2) + 0.205(F3) + 0.153(F4) + 0.148(F5) + 0.0666(F6)

Factors used to calculate PRS are,

- F1: age,
- F2: presence (1) or absence (0) of severe heart disease
- F3: presence (1) or absence (0) of severe pulmonary disease,
- F4: presence (1) or absence (0) of diabetes mellitus,
- F5: performance status index (0-4),
- F6: American Society of Anesthesiologists physiological status classification (1-5)

2. Surgical Stress Score = -0.342 + 0.0139(F1) + 0.0392(F2) + 0.352(F3)

- F1: blood loss/ body weight (g/kg),
- F2: operation time (h)
- F3: extent of skin incision

3. Comprehensive Risk Score = -0.328 + 0.936 (PRS) + 0.976 (SSS)

Performance status index: (described by Japanese cancer society)

Grade 0 – fully active and able to perform all normal activities without any restriction

Grade 1 – restricted strenuous physical activity but ambulatory and able to carry out work of light or sedentary nature

Grade 2 – Ambulatory and capable of all self care but unable to carry out any work activities for up to or greater than 50% of walking hours

Grade 3 – Capable of only limited self-care and confined to bed or chair for more than 50% of walking hours

Grade 4 – completely disabled, unable to perform any self-care and totally confined to bed.

American society of Anesthesiologist classification (ASA) scoring:

Class 1 – Normal healthy state

Class 2 – Mild systemic disease

Class 3 – Severe systemic disease but not incapacitating

Class 4 – Incapacitating systemic disease that is a constant threat to life

Class 5 – Moribund, not expected to survive for 24hours with or without surgery

MATERIALS AND METHODS

- **SOURCE OF DATA:**
  - 50 patients admitted in Coimbatore Medical College and Hospital undergoing laparotomy involving intestinal anastomosis
- **STUDY PLACE**:
  - Coimbatore Medical College and Hospital.
- **STUDY DESIGN**:
  - Prospective Observational Study
- **SAMPLE SIZE:**
  - 50 PATIENTS
- **STUDY PERIOD:**
  - SEPTEMBER 2013 – SEPTEMBER 2014
- **INCLUSION CRITERIA**
  - Patients undergoing abdominal surgeries (Emergency or Elective) involving anastomosis of bowel.
  - Age > 18yrs

- **EXCLUSION CRITERIA**

    - Patients initially underwent a diversion procedure with a stoma and having Re-laparotomy for stoma reversal

50 patients admitted in general surgery department in Coimbatore Medical College undergoing laparotomy involving bowel anastomosis will be studied prospectively during study period

- A detailed clinical history was taken from all the patients consented for study. Thorough physical examination was done for all the patients
- Patients were evaluated preoperatively with routine hematological and radiological investigations needed for the surgery
- Intra operative details like duration of surgery, amount of blood loss and type of incision was noted
- Followed up post operatively and observed for any complications particularly anastomotic leak

Evaluation of physiological ability and surgical stress (E-PASS) score was estimated by calculating Preoperative Risk Score (PRS) Surgical Stress Score (SSS) and Comprehensive Risk Score (CRS). These scores were calculated and individually analysed regarding prediction of anastomotic leak.

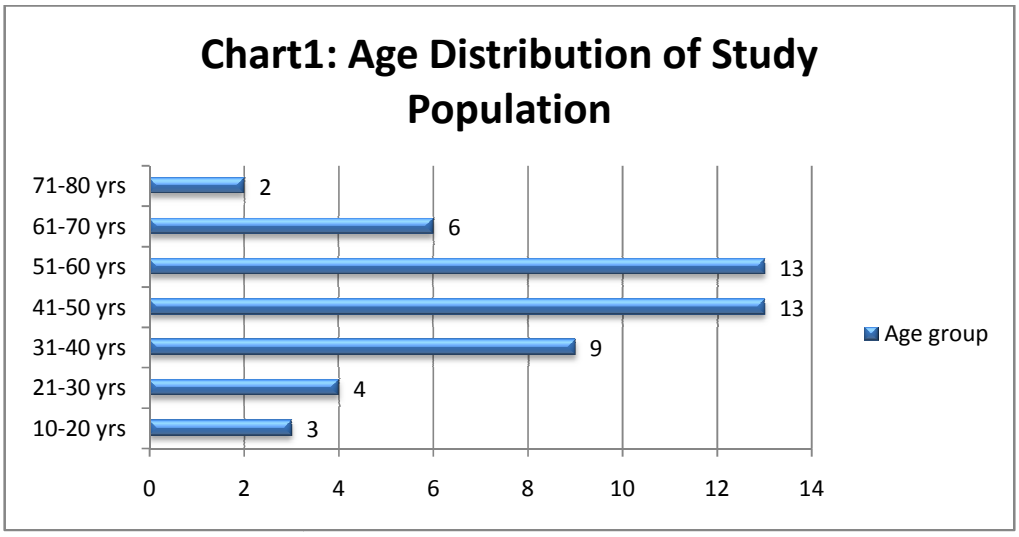
RESULTS

AGE DISTRIBUTION

Most common age group undergoing intestinal anastomosis among present study population is 41-60yrs. Among 50 patients, 16 are in this age group. Mean age is 47.96years. Lowest age is 13 years and highest age is 78 years.

Table 1: Age distribution of study population

Age group	No.	Percent
10-20 yrs	3	6.0
21-30 yrs	4	8.0
31-40 yrs	9	18.0
41-50 yrs	13	26.0
51-60 yrs	13	26.0
61-70 yrs	6	12.0
71-80 yrs	2	4.0
Total	50	100.0

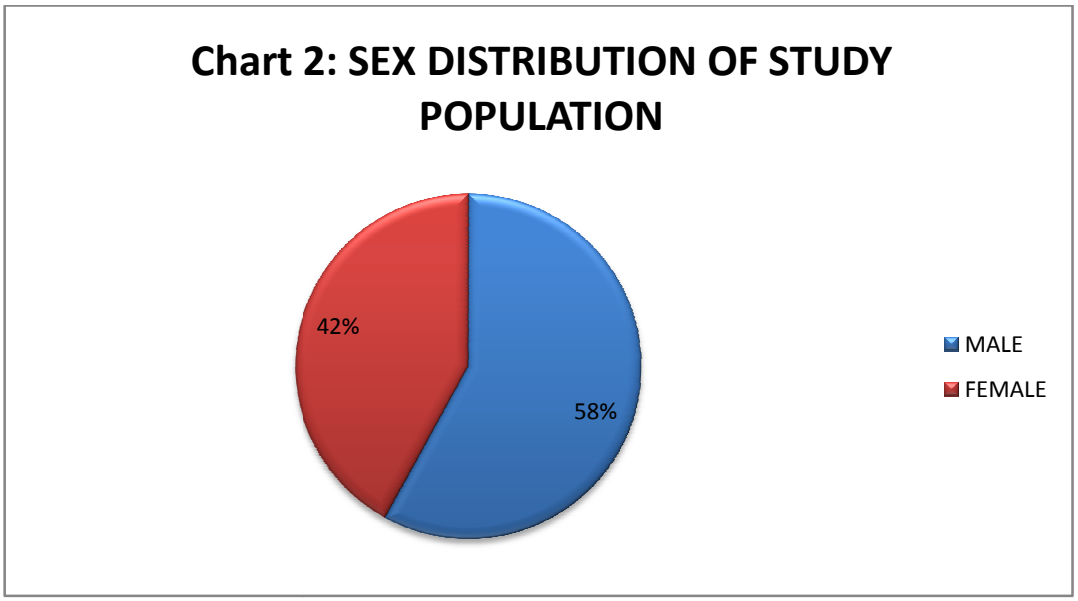


SEX DISTRIBUTION

Our study population consists of 50cases in total. Out of which there are 29male cases and 21 female cases.

Table 2 : Sex Distribution of study population

	No.	Percent
Male	29	58.0
Female	21	42.0
Total	50	100.0



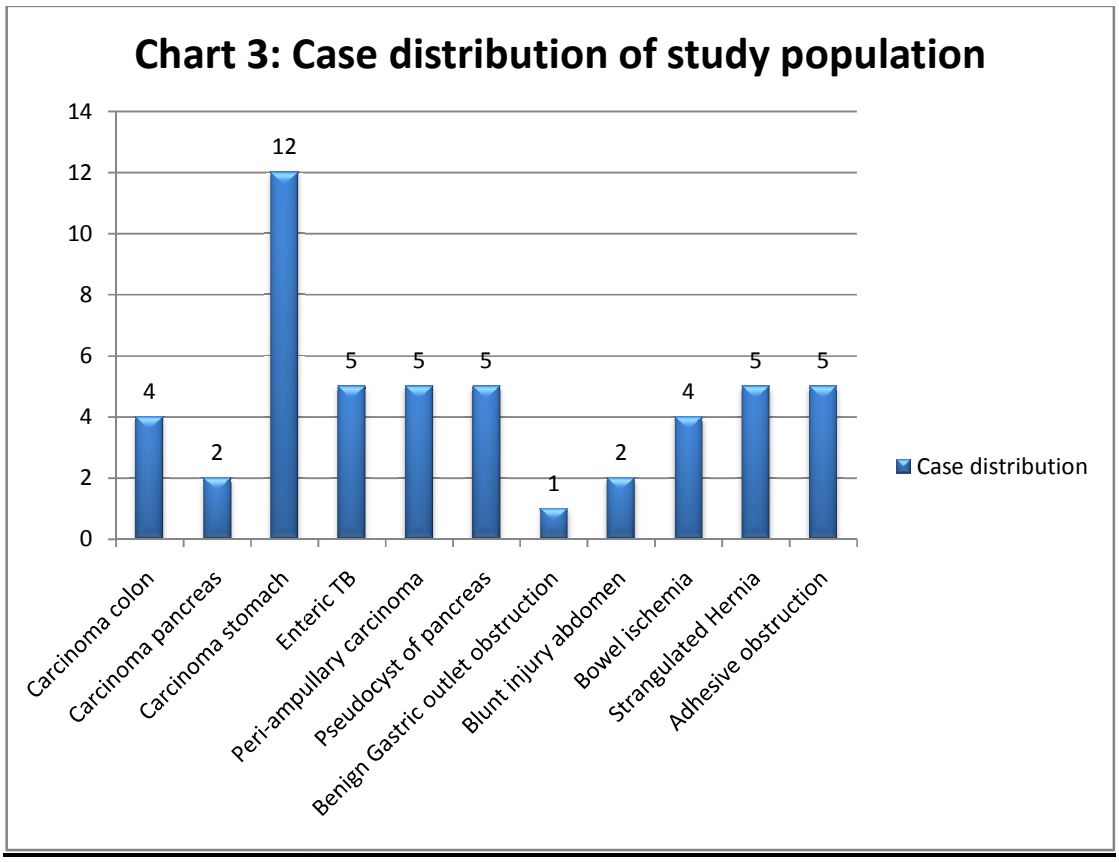
CASE DISTRIBUTION

Table 3: Distribution of cases in study population

DIAGNOSIS	NUMBER OF CASES
1. Carcinoma colon	4
2. Carcinoma pancreas	2
3. Carcinoma stomach	12
4. Enteric TB	5
5. Peri-ampullary carcinoma	5
6. Pseudocyst of pancreas	5
7. Benign Gastric outlet obstruction	1
8. Blunt injury abdomen	2
9. Bowel ischemia	4
10. Strangulated Hernia	5
11. Adhesive obstruction	5
Total cases	**50**

In the study population 24 patients had carcinoma of which carcinoma stomach was present in about 12 cases. 2 cases are due to blunt trauma to abdomen. Benign causes includes Benign gastric outlet obstruction and pseudocyst of pancreas. Rest of the cases are due bowel obstruction due to various other causes.

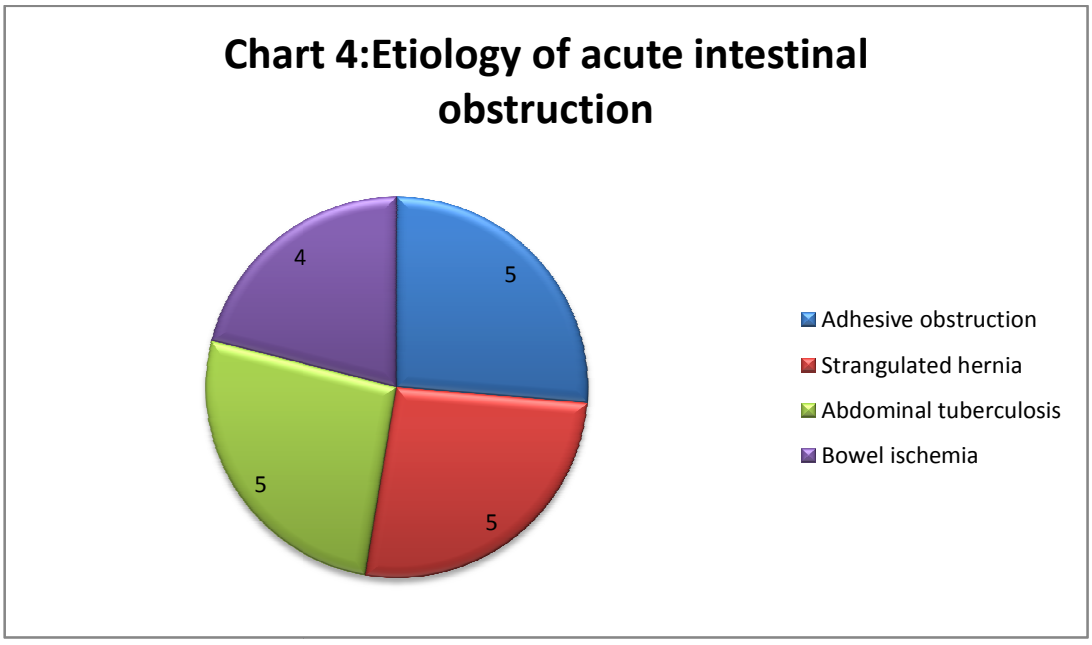
Infective causes include enteric TB which is present in 5 cases.



ACUTE INTESTINAL OBSTRUCTION

Table 4: Etiology of acute intestinal obstruction

ETIOLOGY	NUMBER OF CASES
1. Adhesive obstruction	5
2. Strangulated Hernia	5
3. Abdominal tuberculosis	5
4. Bowel ischemia	4

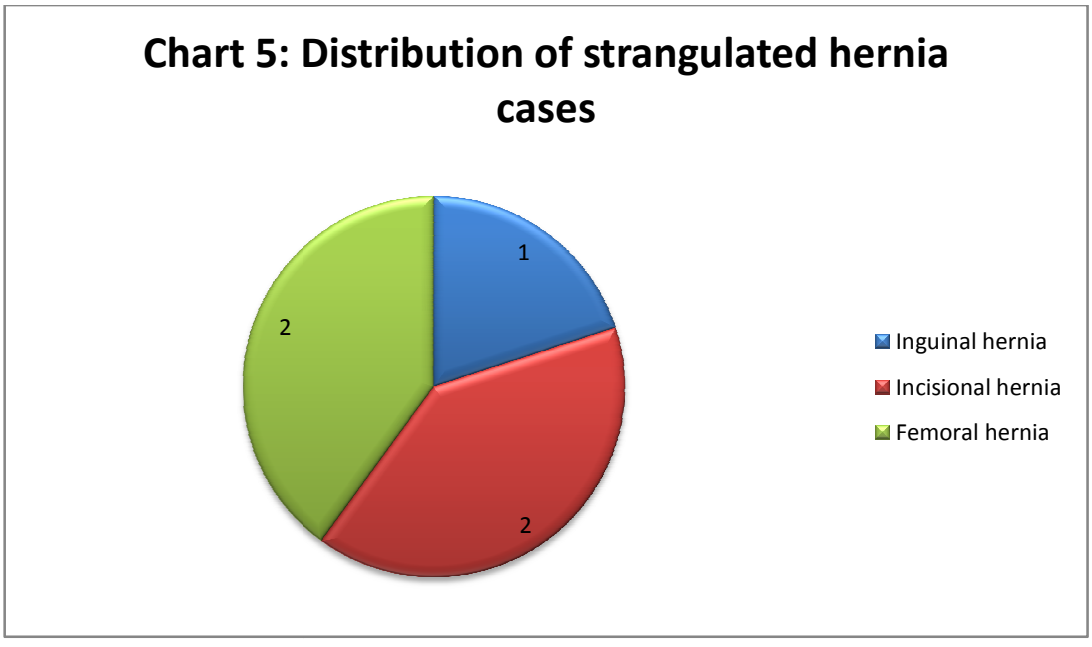


Distribution of hernia cases:

Among 5 patients with strangulated hernia only 1 patient had inguinal hernia, 2 patients had femoral hernia and 2 patients had incisional hernia

Table 5: Distribution of Hernia cases in acute intestinal obstruction

Type of Hernia	No. Of patients
Inguinal hernia	1
Incisional hernia	2
Femoral hernia	2

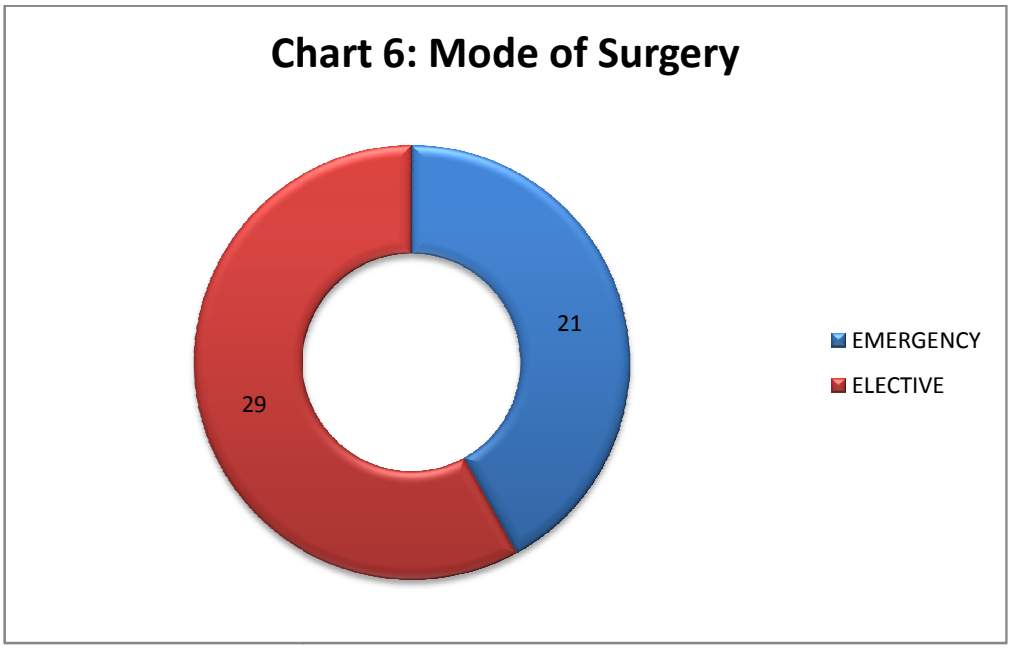


MODE OF SURGERY

Among 50 cases in study population 21 cases were taken as emergency without any bowel preparation while rest 29 cases as taken electively with proper bowel preparation.

NO. ELECTIVE CASES – 29

NO. OF EMERGENCY CASES – 21



INCIDENCE OF HEART DIESEASE IN STUDY POPULATION

In the study population 3 patients had heart disease which constitutes around 6%

Table 6: Heart disease in study population

	No.	Percent
No	47	94.0
Yes	3	6.0
Total	50	100.0

INCIDENCE OF PULMONARY DISEASE IN STUDY POPULATION

In the study population 12 patients had pulmonary disease which constitutes around 24% of the total study population.

Table 7: Pulmonary disease in study population

	No.	Percent
No	38	76.0
Yes	12	24.0
Total	50	100.0

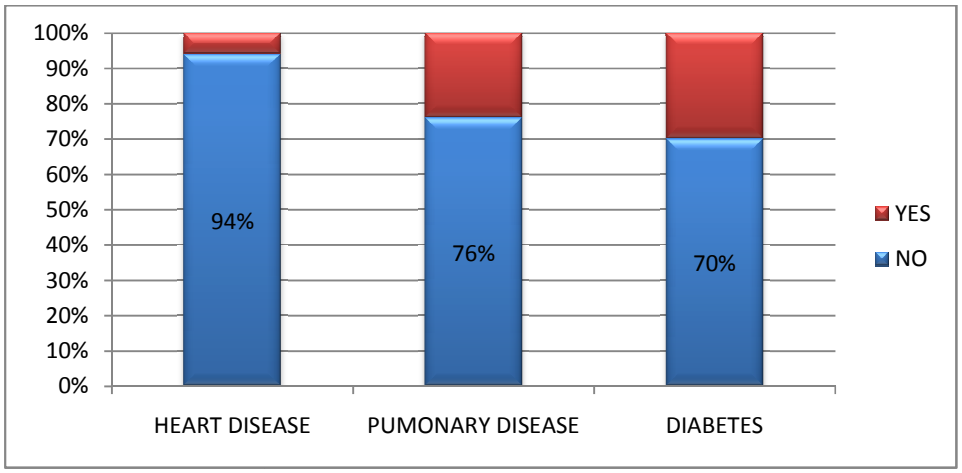
INCIDENCE OF DIABETES MELLITUS IN STUDY POPOULATION

In the study population around 15 patients had diabetes mellitus which constitutes about 30% of the total study population.

Table 8: Diabetes in study population

	No.	Percent
No	35	70.0
Yes	15	30.0
Total	50	100.0

Chart7: Incidence of heart disease, pulmonary disease and diabetes in the study population

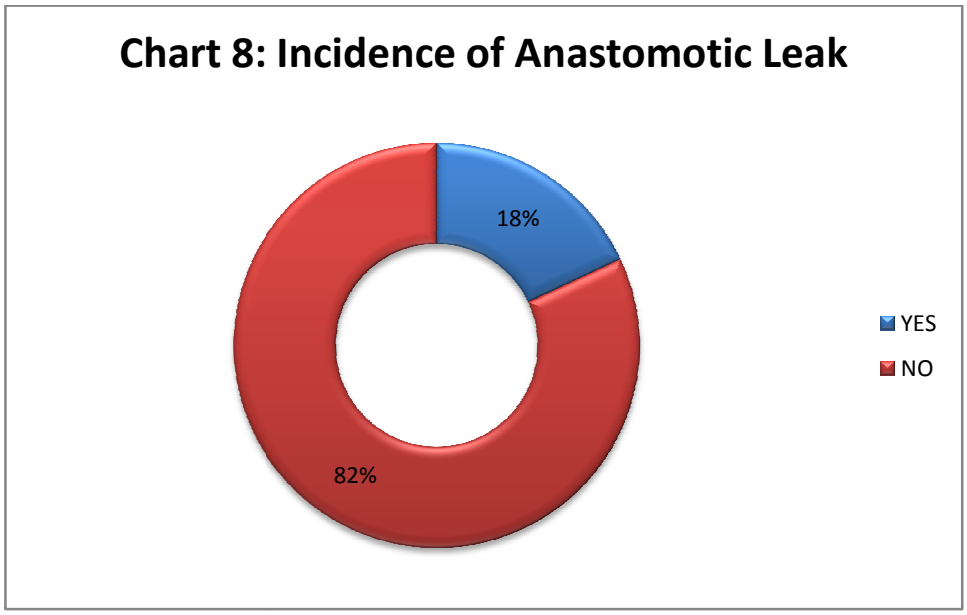


INCIDENCE OF ANASTOMOTIC LEAK

Table 9: Incidence of anastomotic leak

	No.	Percent
No	41	82.0
Yes	9	18.0
Total	50	100.0

Out of 50 cases, 9 cases had postoperative anastomotic leak. Incidence of anastomotic leak is around 18%.



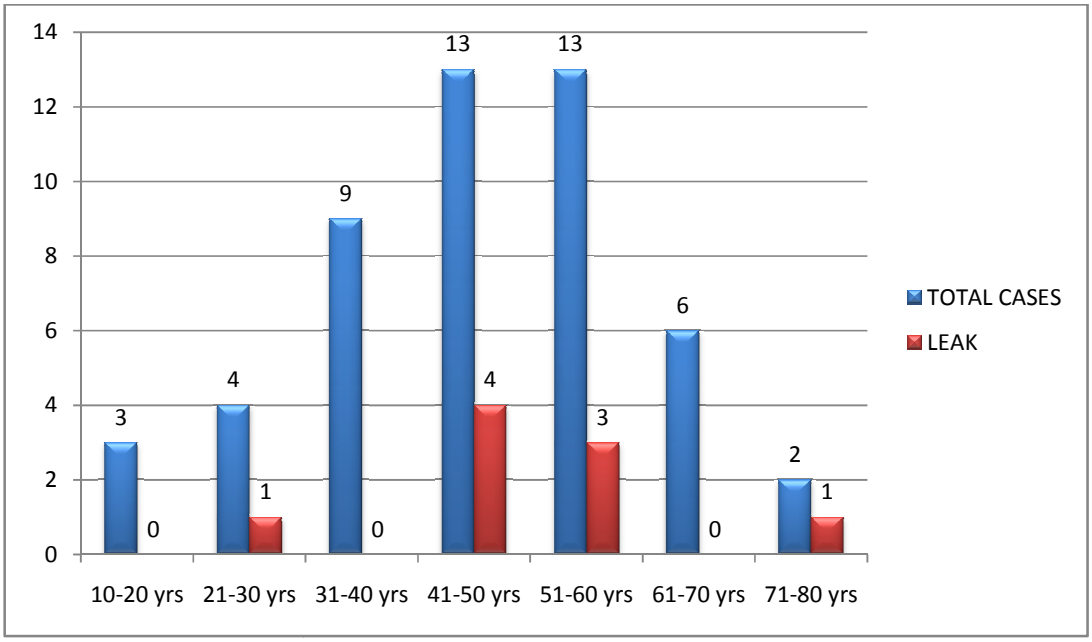
Comparison of age and anastomotic leak

Among 9 cases with anastomotic leak 4 cases were in 41-50yrs group. 3 cases were in 51-60yrs group. And 1 case each in 21-30yrs group and 71-80yrs group.

Table 10: Age wise distribution of patients with anastomotic leak

Age group	Total no. Of cases	No. Of cases with anastomotic leak
10-20 yrs	3	0
21-30 yrs	4	1
31-40 yrs	9	0
41-50 yrs	13	4
51-60 yrs	13	3
61-70 yrs	6	0
71-80 yrs	2	1
Total	50	9

Chart 9: Age distribution of cases with anastomotic leak



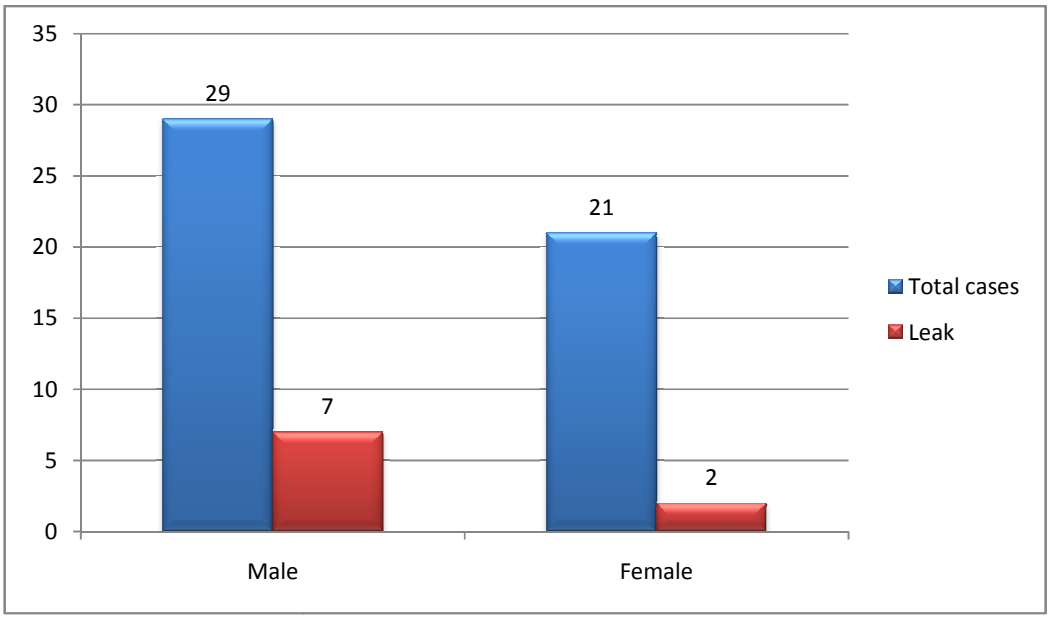
Comparison of sex and anastomotic leak

Out of 9 patients with anastomotic leak 7 patients are male and 2 patients are female.

Table 11: Sex distribution of patients with anastomotic leak

	Total no. of cases	No.of cases with anastomotic leak	Percentage
Male	29	7	24.14%
Female	21	2	9.52%

Chart 10: Sex distribution of cases with anastomotic leak

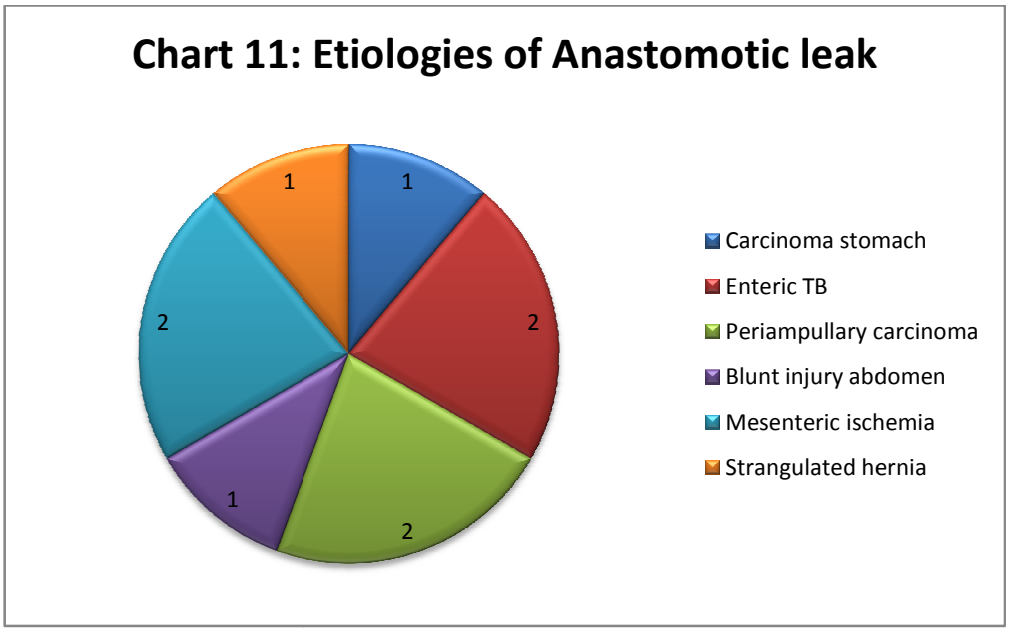


Comparison of diagnosis and anastomotic leak

Among 9 patients with anastomotic leak, the diagnosis for which they are operated are as follows

Table 12: Etiologies of anastomotic leak

DIAGNOSIS	NUMBER OF CASES	Number of cases with anastomotic leak
1. Carcinoma stomach	12	1
2. Enteric TB	5	2
3.Peri-ampullary carcinoma	5	2
4. Blunt injury abdomen	2	1
5. Mesenteric ischemia	4	2
6. Strangulated Hernia	5	1
Total cases	**50**	**9**



Anastomotic leak in emergency and elective surgeries

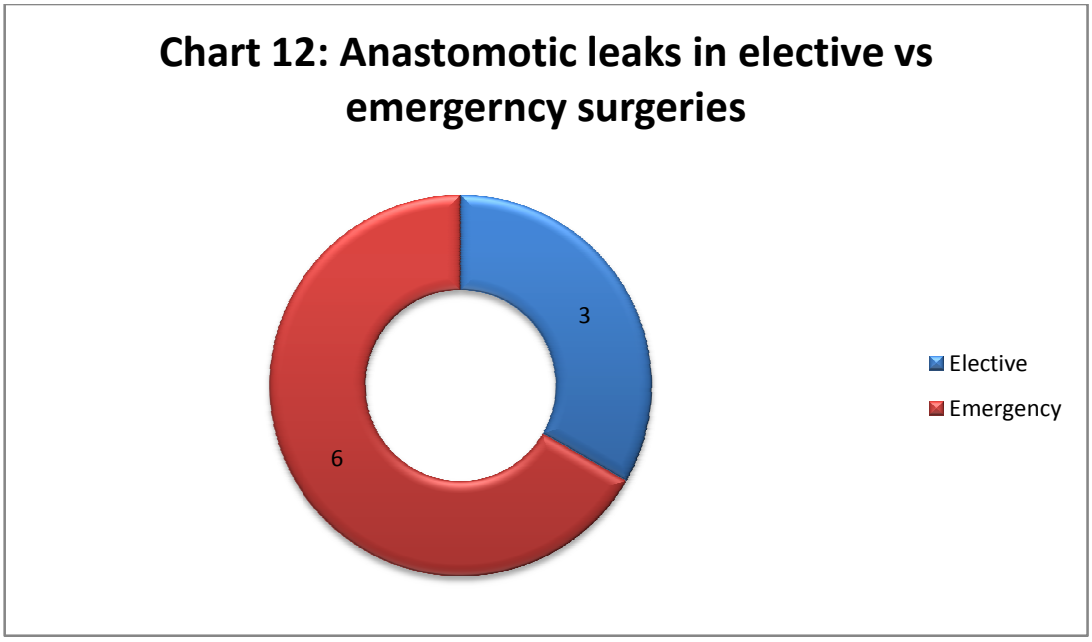
Out of 9 cases with anastomotic leak, two-thirds were emergency cases and rest one-third were elective cases.

Out of 29 elective surgeries 3 patients had postoperative anastomotic leak which is around 10%. In emergency cases out of 21 patients 6 had postoperative anastomotic leak which is around 28.5%.

Table 13: Anastomotic leaks in elective and emergency cases

	Leak	No leak	Total cases
Elective	3	26	29
Emergency	6	15	21

Association between anastomotic leak and emergency surgery is found to be significant at 10% level. Chi-square value – 2.7414. p value – 0.09.



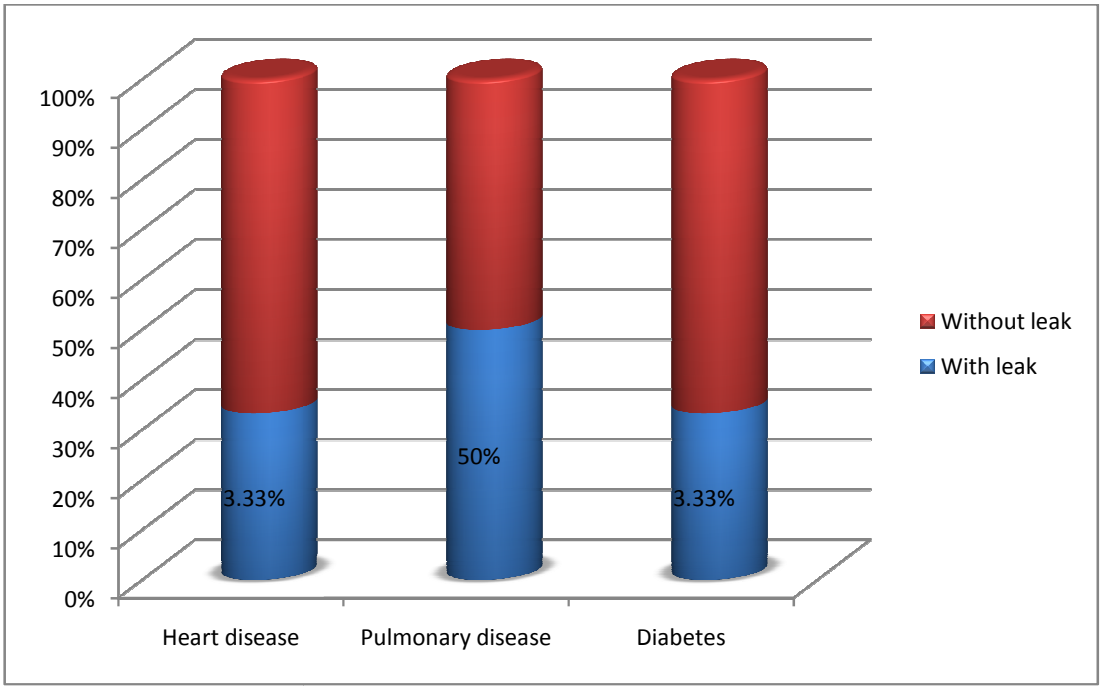
Analysis of presence of heart disease, pulmonary disease and diabetes among cases with anastomotic leak:

Among three patients with heart disease in study population, one developed postoperative anastomotic leak which is about 33.33%. One half of the patients with pulmonary disease developed anastomotic leak in the post operative period i.e., 6 among 12 patients. Among 15 diabetic patients, around one-third had postoperative anastomotic leak.

Table 14: Anastomotic leaks in patients with comorbid conditions

Co-morbid condition	Total cases	With leak	Without leak
Heart disease	3	1(33.33%)	2(6.66%)
Pulmonary disease	12	6(50%)	6(50%)
Diabetes	15	5(33.33%)	10(6.66%)

Chart 13: Anastomotic leaks in patients with comorbid conditions



Test for significance of co-morbid conditions

Presence of comorbid conditions which are included in 'E-PASS' scoring system and their significance in association with the anastomotic leak is tested using chi-square method and results are as follows.

Pulmonary disease:

		Leak				TOTAL	
		No		Yes		No.	%
		No.	%	No.	%		
Pulmonary Disease	No	35	92.1	3	7.9	38	100.0
	Yes	6	50.0	6	50.0	12	100.0
TOTAL		41	82.0	9	18.0	50	100.0

Chi-square tests

	Value	df	P value
Chi-Square	8.287	1	.004

Diabetes mellitus:

		Leak				TOTAL	
		No		Yes		No.	%
		No.	%	No.	%		
Diabetes mellitus	No	31	88.6	4	11.4	35	100.0
	Yes	10	66.7	5	33.3	15	100.0
TOTAL		41	82.0	9	18.0	50	100.0

Chi-square tests

	Value	df	P value
Chi-Square	2.091	1	.148

Heart disease:

		Leak				TOTAL	
		No		Yes		No.	%
		No.	%	No.	%		
Heart disease	No	39	82.97	8	17.03	47	100.0
	Yes	2	6.67	1	3.33	3	100.0
TOTAL		41	82.0	9	18.0	50	100.0

Chi square tests

	Value	df	P value
Chi-Square	0.5084	1	0.475

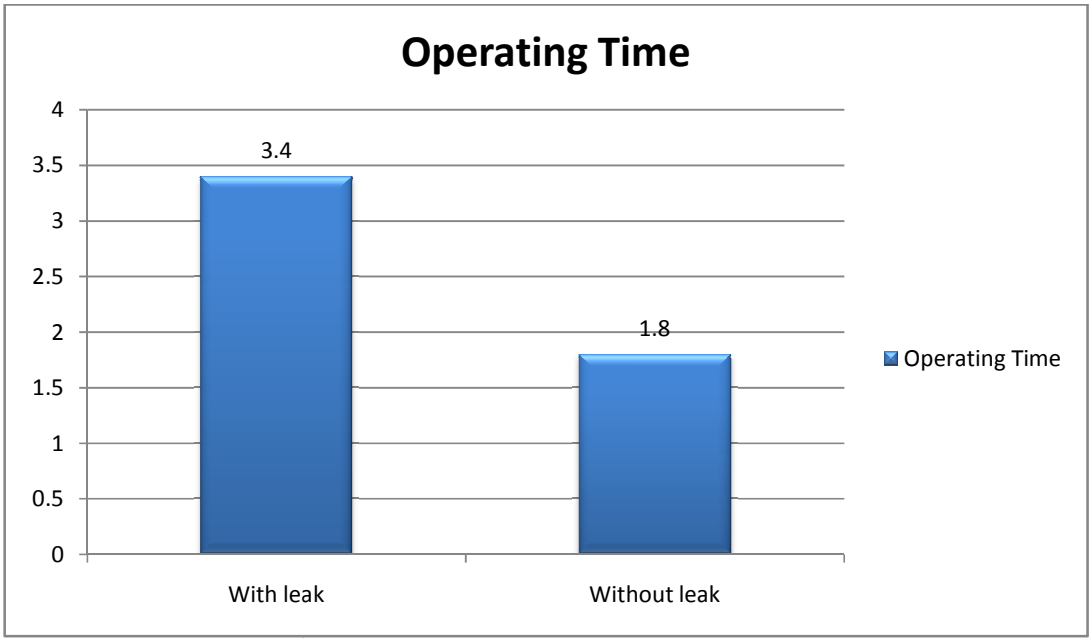
On conducting chi-square tests Pulmonary disease is found to be more significantly associated with the post operative incidence of anastomotic leak with p-value of 0.04 (significant at 5% level) than Diabetes and Heart disease whose p-value are 0.148 and 0.475 respectively.

Operating time

Mean operating time for patients without anastomotic leak: **1.8hours**

Mean operating time for patients with anastomotic leak: **3.4hours**

Chart 14: Comparison of operating time in patients with anastomotic leak and without leak

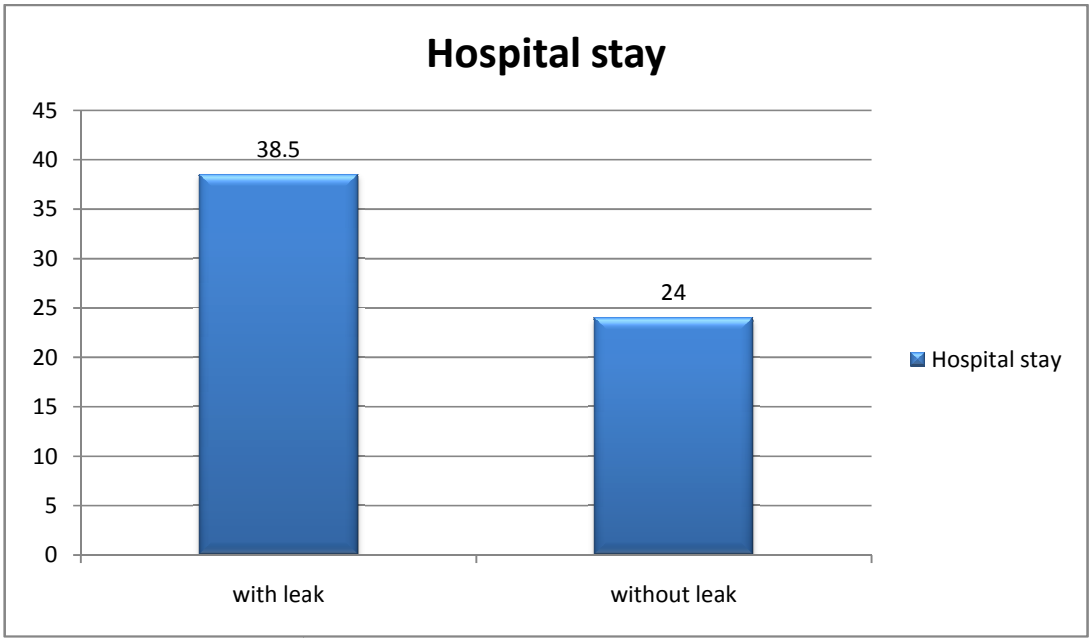


Duration of Hospital stay

Mean duration of Hospital stay among patients with anastomotic leak:**38.5days**

Mean duration of Hospital stay among patients without leak: **24days**

Chart 15: Comparison of Duration of Hospital Stay in patients with anastomotic leak and without leak



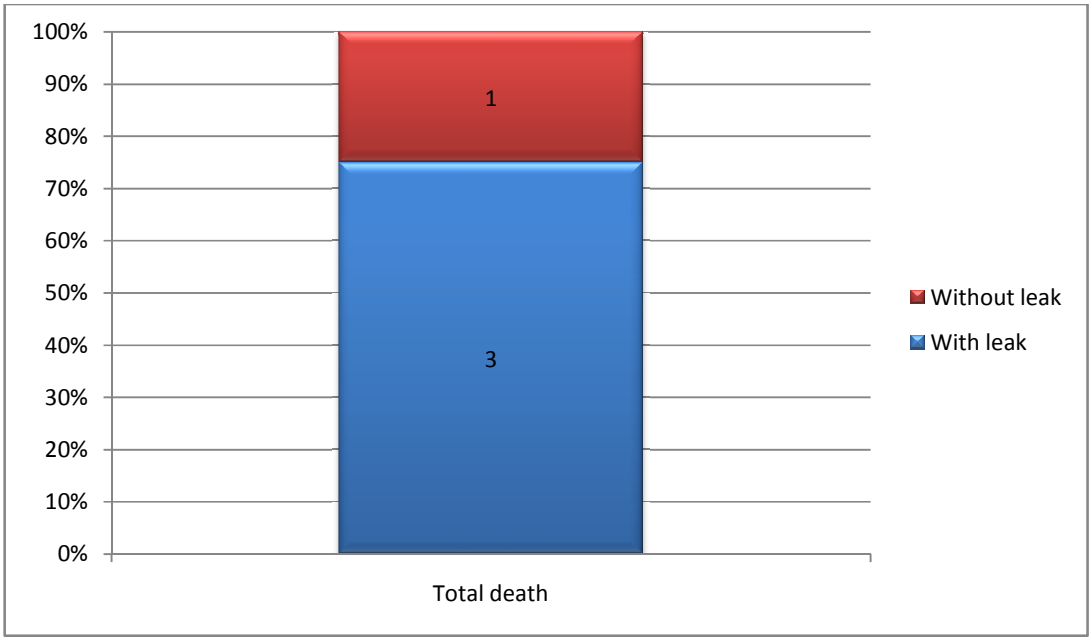
Mortality Rates

Total number of death: 4 Patients

Death among patients with anastomotic leak: 3out of 9Patients (33.33%)

Death among patients without anastomotic leak: 1 out of 41 patients (2.43%)

Chart 16: Death in patients with anastomotic leak and without anastomotic leak



Relevance E-pass scoring system in association with incidence of post operative anastomotic leak

Three scores of E-pass scoring system namely Pre operative Risk Score (PRS), Surgical Stress Score (SSS) and Comprehensive Risk Score (CRS) for each patient were computed. Mean value of each score among patients with anastomotic leak and among patients without anastomotic leak are calculated. And their significance is tested using T-test for equity of means.

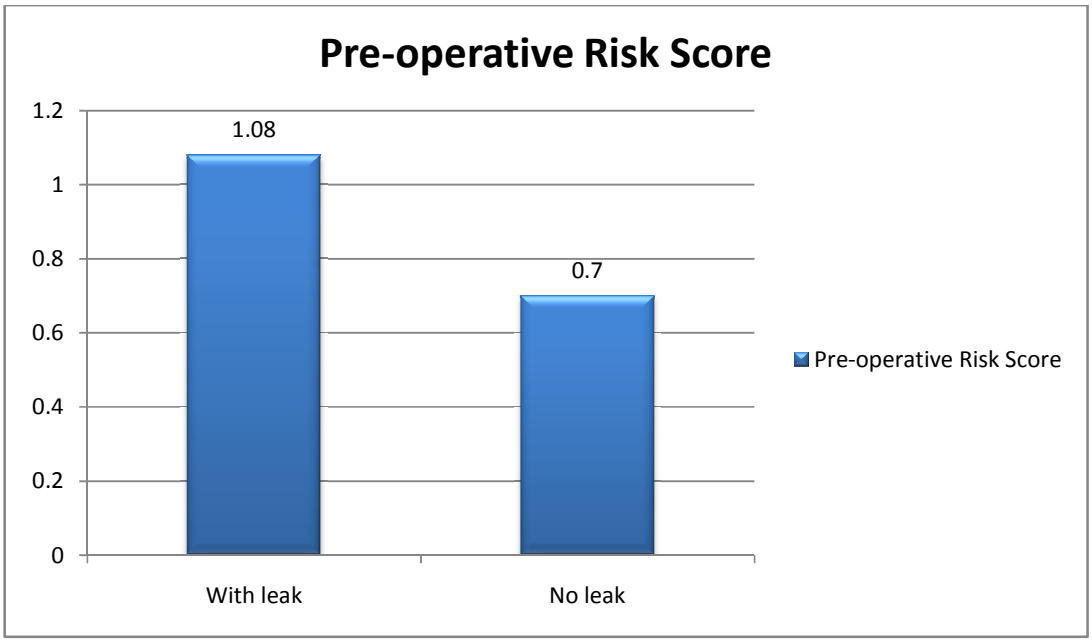
Pre operative risk score (PRS)

Mean PRS for patients with anstomotic leak: 1.08; S.D. – 0.25

Mean PRS for patients without anastomotic leak: 0.70; S.D. – 0.23

		Preoperative Risk Score (PRS)		
		Mean	**S.D**	**No.**
Leak	**No**	.70	.23	41
	Yes	1.08	.25	9

Chart 17: Comparison of mean PRS in patients with leak and without leak



T-test for equality of means:

t	df	P-value
4.401	48	0.01

Pre-operative Risk Score was compared between patients who had leak and those who have not had leak. The mean value of Pre-operative Risk Score for patients with anastomotic leak is 1.08 with SD of 0.25. It is significantly higher than the patients who had no anastomotic leak which is 0.70 with SD of 0.23. The t-test for equity of means conducted was found to be significant at 0.01 level ($p<0.01$).

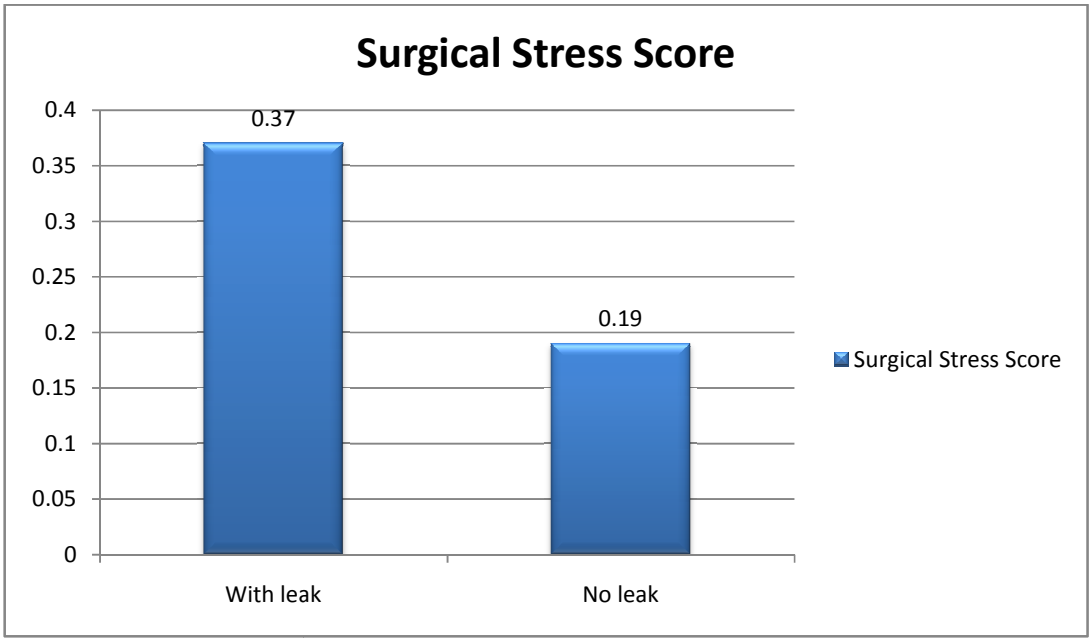
Surgical Stress score

Mean SSS for patients with anstomotic leak: 0.37; S.D. – 0.19

Mean SSS for patients without anastomotic leak: 0.19; S.D. – 0.09

		Surgical Stress Score (SSS)		
		Mean	**S.D**	**No.**
Leak	**No**	.19	.09	41
	Yes	.37	.19	9

Chart 18: Comparison of mean SSS in patients with leak and without leak



T-test for equality of means:

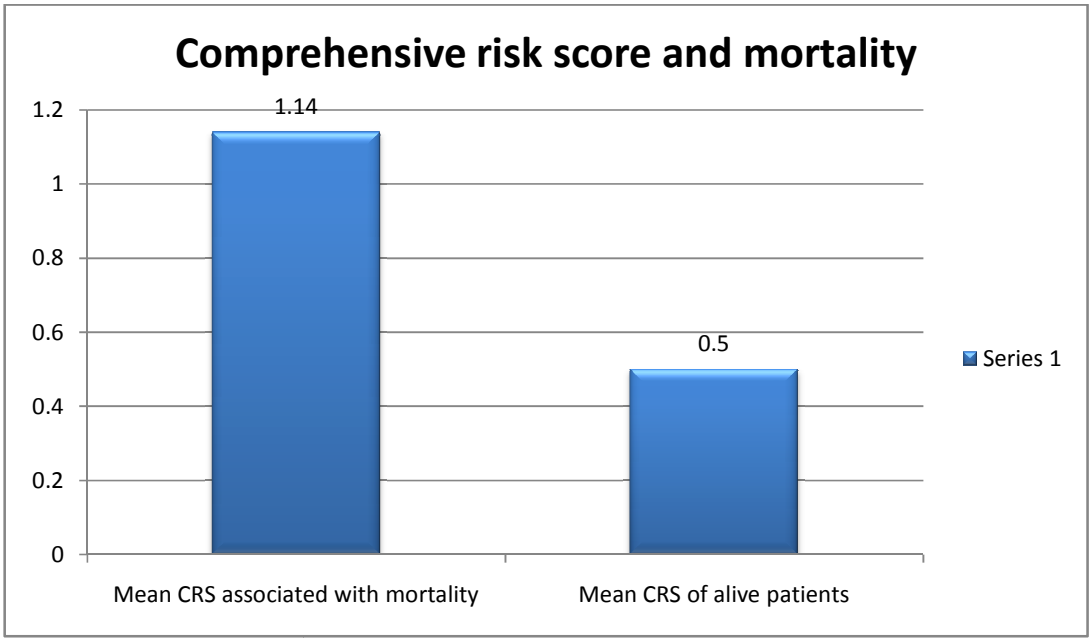
t	df	p-value
4.239	48	0.01

Surgical Stress Scores were compared between patients who had leak and those who have not had leak. The mean value of Surgical Stress Score for patients with anastomotic leak is 0.37 with SD of 0.19. It is significantly higher than the patients who had no anastomotic leak which is 0.19 with SD of 0.09. The t-test for equity of means conducted was found to be significant at 0.01 level ($p<0.01$).

Comprehensive Risk Score

Mean CRS among patient who died in post operative period is 1.14 and among normal patients is 0.5.

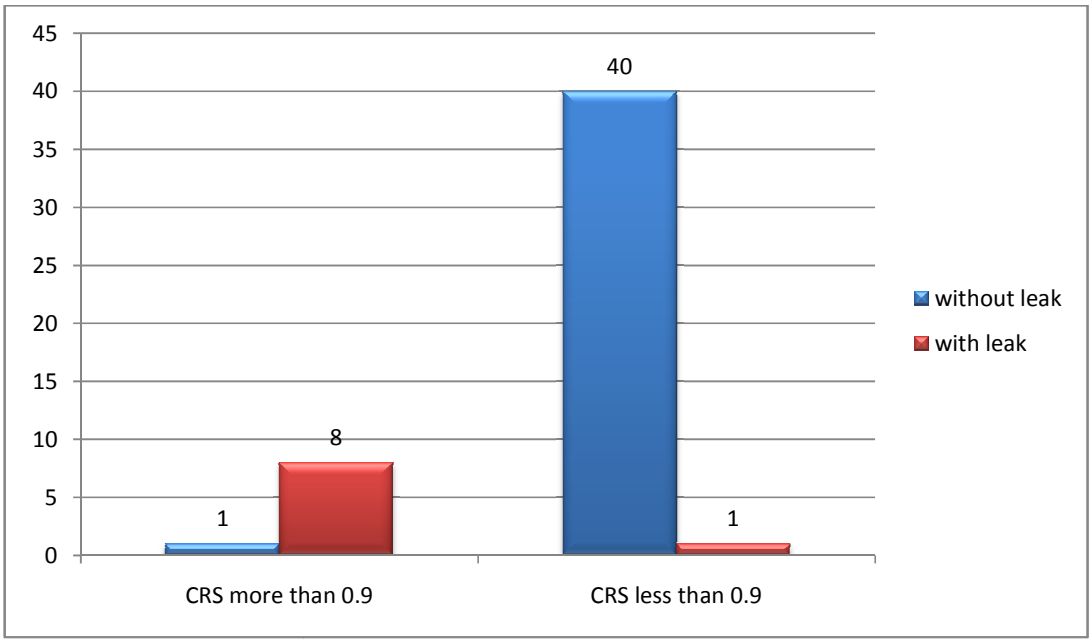
Chart 19: Comparison of mean CRS with mortality



Among nine patients with Comprehensive Risk Score more than 0.9, eight patients had postoperative anastomotic leak. Among 41 patients with Comprehensive Risk Score less than 0.9, only one patient had post operative anastomotic leak.

	ANASTOMOTIC LEAK	NO LEAK
CRS >0.9	8	1
CRS <0.9	1	40

Chart 20: Comparison of patients with CRS more than 0.9 and CRS less than 0.9



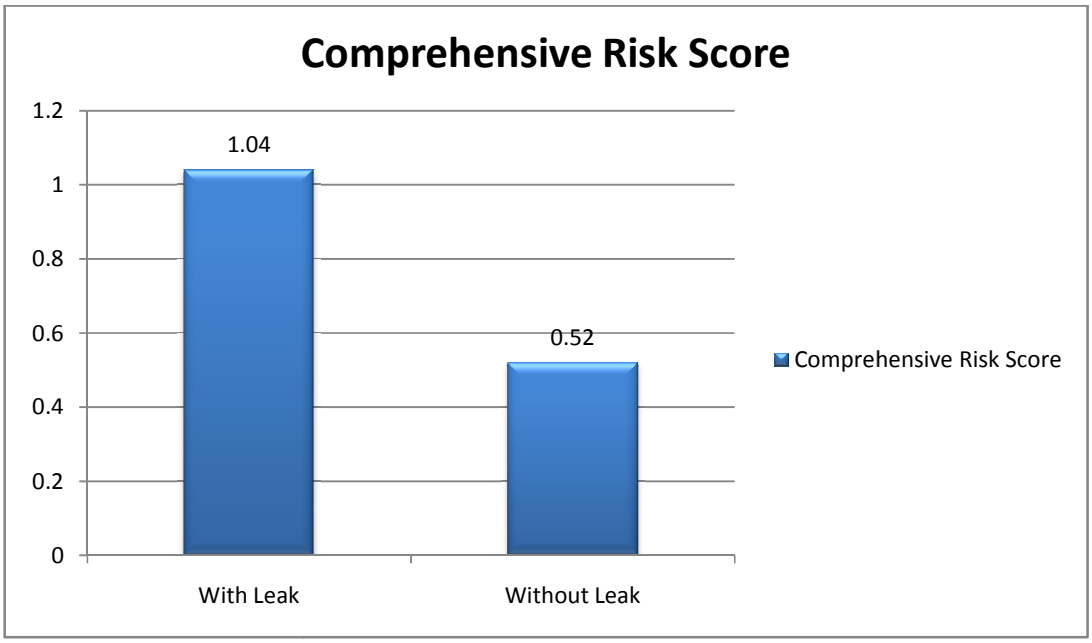
CRS more than 0.9 is significantly associated with the incidence of anastomotic leak ($p<0.01$)

Mean CRS for patients with anstomotic leak: 1.04; S.D. – 0.20

Mean CRS for patients without anastomotic leak: 0.52; S.D. – 0.23

		Comprehensive Risk Score (CRS)		
		Mean	**S.D**	**No.**
Leak	**No**	.52	.23	41
	Yes	1.04	.20	9

Chart 21: Comparison of mean CRS in patients with leak and without leak



T-test for equality of means:

t	df	p-value
6.253	48	0.01

Comprehensive Risk Scores were compared between patients who had leak and those who did not had leak. The mean value Comprehensive Risk Score for patients with anastomotic leak is 1.04 with SD of 0.20. It is significantly higher than the patients who had no anastomotic leak which is 0.52 with SD of 0.23. The t-test for equity of means conducted was found to be significant at 0.01 level ($p<0.01$).

DISCUSSION

Anastomotic leak is a disastrous complication which is frequently encountered by a general surgeon in post operative ward. Anastomotic leak significantly increases duration of hospital stay, morbidity and mortality associated with the surgery. Incidence of anastomotic leak varies from 1.5% to 27% depending upon various factors. Many studies have identified several risk factors for disruption of anastomotic sutures such as male gender, ASA score, excessive smoking, low preoperative serum albumin, increased operating time and amount of blood loss[23,24]. But not many studies are available to predict the actual incidence of anastomotic leakage. This study is an effort to predict the anastomotic leakage using 'E-PASS' scoring system. This scoring system is based on the hypothesis that patients homeostasis is disturbed when the surgical stress overwhelms the physiological reserve of the patient.

E-pass scoring system consists of Pre-operative risk score (PRS), Surgical Stress Score (SSS) and Comprehensive Risk Score (CRS). PRS quantifies the pre operative physiological status of the patient using patients age, presence or absence of severe heart disease, presence or absence of severe pulmonary disease, presence or absence of diabetes mellitus, performance status index as defined by Japanese oncological society and ASA score. PRS gives rough estimate of deviation of

physiological status of the patient which would contribute to the postoperative complications.

Surgical Stress Score (SSS) quantifies the stress applied to the patients homeostasis in the form of surgery using amount of blood loss, length of operating time and type of incision.

Comprehensive Risk Score is a score combining PRS and SSS, thus giving an absolute number to the amount of 'surgical stress' undergone by the patient and his pre operative physiological status.

In the present study, study population consists of 50 patients out of which 29 were male patients (58%) and 21 were female patients (42%).

Regarding age group, majority of the patients were in 41-60 yrs of age. 26 patients were in this age group. Mean age is 47.96years. Youngest patient in the study is 13 years old and oldest patient is 78 years old.

In the present study, incidence of anastomotic leakage is 18%. Out of 50 patients in study, nine patients had postoperative anastomotic leak.

Anastomotic leak is more commonly seen among male patients[23]. Among 29 male patients 7 had anastomotic leak and among 21 female patients 2 had anastomotic leak. (p=0.184). Male to female ratio is 3.5:1

Most common age group with anastomotic leak is 41-50years. 4 patients in this group had anastomotic leak. 3 patients in 51-60 yrs age group had anastomotic leak. 1 patient each in 21-30years group and 71-80years age group also had leak.

Regarding etiology of resection and anastomosis, majority were due to acute intestinal obstruction. Among 19 cases with acute intestinal obstruction(38%). Post operative adhesions (5 patients) ,strangulated hernia (5patients) and abdominal tuberculosis causing bowel obstruction (5 patients)were most common causes of acute intestinal obstruction with bowel gangrene. 4 cases with mesenteric ischemia presented as acute intestinal obstruction. Other emergency surgeries were due to blunt injury abdomen in 2 patients.

Inguinal hernia is the commonest type of hernia. But in the present study, among 5 patients with strangulated hernia only one had inguinal hernia. Two patients had incisional hernia and other two had femoral hernia.

Other patients were treated in elective setting. Majority among elective surgeries were due to carcinoma stomach (12 patients). In cases of carcinoma stomach surgeries were either gastrectomy with billroth II anastomosis or just anterior gastrojejunostomy to relieve gastric outlet obstruction in inoperable cases.

4 cases are due to carcinoma colon. All cases with carcinoma colon were operated in elective setting. Out of which 3 are right sided pathology for which right hemicolectomy was done. Left hemicolectomy done for one patient with carcinoma near splenic flexure. 2 cases were inoperable carcinoma head of pancreas for which triple anastomosis was done. There were 5 cases with periampullary carcinoma treated with whipples surgery. Another 5 cases were pseudocyst of pancreas. Among them 4 cases were treated with cystogastrostomy and 1 case with cysto-jejunostomy. 1 cases was a gastric outlet obstruction due to benign stricture which was treated with gastrojejunostomy.

Anastomotic leakage is commonly seen in emergency surgeries than in elective surgeries. Incidence of anastomotic leak is around 10% in elective surgeries and 28.5% in emergency surgeries. Out of 21 emergency cases 6 had anastomotic leak and out of 29 elective cases 3 had anastomotic leak. In our present study association between anastomotic leak and emergency surgery is found to be significant at 10% level.($p=0.09$). Increased incidence of anastomotic leak in cases undergoing emergency surgery is noted in many studies which is due to many factors such as faecal contamination of gut, poor general condition, poor nutritional status, impaired oxygen transport to the peri-anastomotic site due to anaemia, hypoxemia and unprepared bowel. Though conflicts

are present regarding bowel preparation[15] in elective cases, increased bacterial proliferation and sepsis in emergency situations affects healing of anastomosis.

In emergency surgeries anastomotic leaks were seen in 2 cases with mesenteric ischemia, 2 cases with abdominal tuberculosis, 1 patient with blunt abdominal injury and 1 patient with strangulated hernia. As expected incidence of anastomotic leak was more in patients with mesenteric ischemia. In present study 50% of patients with mesenteric ischemia developed anastomotic leak. Among those two patients one patient died in postoperative period who presented with extensive gangrene of small bowel.

Viability of bowel ends must be assessed intra operatively in cases with mesenteric ischemia. If viability is in doubt few studies suggest to bring both edges of bowel as an ostomy and re-laparotomy can be performed once patients condition improves. Another group with more incidence of anastomotic leak is in cases with abdominal TB. In cases with extensive abdominal tuberculosis wound healing is impaired and it leads to anastomotic leak.

Three important co-morbid conditions are taken into account in E-PASS scoring system. They are presence of severe heart disease, severe pulmonary disease and diabetes mellitus. Apart from their contribution to

the scoring system, effect of each co-morbid condition on the incidence of anastomotic leak is also studied.

In the study population 12 patients had pulmonary disease, 15 patients had diabetes and 3 patients had heart disease.

Among 12 patients with pulmonary disease 50% of them (6 patients) had postoperative anastomotic leak. Association of pulmonary disease with anastomotic leak is tested using chi-square test. Chi-square value – 8.287, p value - .004.($p<0.01$) which is significant at 1% level. Among 15 patients with diabetes mellitus 5 of them had post operative anstomotic leak which is aroud 33.3% ($p=0.148$). Among 3 patients with heart disease 1 patient had anastomotic leak in postoperative period which amounts to 33.33% ($p=0.475$).

On conducting chi-square tests, Pulmonary disease is found to be more significantly associated with the post operative incidence of anastomotic leak with p-value of 0.04 (significant at 5% level) than Diabetes and Heart disease whose p-value are 0.148 and 0.475 respectively.

Significant association of anastomotic leak with severe pulmonary disease can be explained by the impairment of pulmonary function in emergency cases with increased abdominal compartment pressure.

Michael Quintel et al clearly demonstrated the deleterious effects of increased abdominal compartment pressure in the pulmonary system particularly in previously injured lung[22]. Proper resuscitation and pre op management can improve the pulmonary function in patients with acute abdomen which in turn can increase peri-ananstomotic oxygen tension and prevent development of anastomotic leak in postoperative period. In patients with severely impaired pulmonary status primary anastomosis can be avoided and diversion procedures can done in emergency setting. Definitive procedure could be done after improving the pulmonary function.

Another interesting factor to be noted in this study is mean operating time for patients with anastomotic leak is nearly twice than the patient without any leak. Mean operating time in patients without anastomotic leak is 1.8 hours while mean operating time in patients with anastomotic leak is around 3.4 hours. Though many studies states that duration of time spend under anaesthesia can increase the postoperative morbidity, effect of operating time on incidence post operative complications like anastomotic leak is not well studied.

Length of stay in hospital stay is one of the commonly used statistical term to measure the morbidity associated with any disease. Mean duration of hospital stay for patients with anastomotic leak is 38.5

days and that of others is 24 days. Thus anastomotic leaks increases duration of stay in hospital and thus increasing morbidity associated with the surgical procedure.

Out of 9 patients with anastomotic leak 3 patients died in the postoperative period which is about 33.33%. Among patients without anastomotic leak mortality is around 2%. Thus incidence of anastomotic leak significantly increases morbidity and mortality in the post operative period.

Analysis of E-PASS scoring system:

Three scores of E-pass scoring system namely Pre operative Risk Score (PRS), Surgical Stress Score (SSS) and Comprehensive Risk Score (CRS) for each patient were computed. Mean value of each score among patients with anastomotic leak and among patients without anastomotic leak are calculated. And their significance is tested using T-test for equity of means.

Pre-operative Risk Score was compared between patients who had leak and those who have not had leak. The mean value of Pre-operative Risk Score for patients with anastomotic leak is 1.08 with SD of 0.23. It is significantly higher than the patients who had no

anastomotic leak which is 0.70 with SD of 0.23. The t-test for equity of means conducted was found to be significant at 0.01 level ($p<0.01$).

Surgical Stress Scores were compared between patients who had leak and those who have not had leak. The mean value Surgical Stress Score for patients with anastomotic leak is 0.37 with SD of 0.19. It is significantly higher than the patients who had no anastomotic leak which is 0.19 with SD of 0.09. The t-test for equity of means conducted was found to be significant at 0.01 level ($p<0.01$).

Comprehensive Risk Scores were compared between patients who had leak and those who have not had leak. The mean value Comprehensive Risk Score for patients with anastomotic leak is 1.04 with SD of 0.20. It is significantly higher than the patients who had no anastomotic leak which is 0.52 with SD of 0.23. The t-test for equity of means conducted was found to be significant at 0.01 level ($p<0.01$).

Each scores in E-PASS scoring system is significantly associated with the incidence of post operative anastomotic leak. Comprehensive Risk Score of more than 1.0 is 100% associated with the postoperative anastomotic leak. Among the patients who had anastomotic leak nearly 90% of them had Comprehensive risk score more than 0.9. Calculation of pre operative risk score needs only six variables namely age, presence of co-morbid conditions like pulmonary disease, heart

disease, diabetes, ASA score and performance index score. These details can be quickly obtained preoperatively. For calculation of surgical stress score three variables are needed namely approximate operating time, expected blood loss and intended surgical incision. These factors can also be judged pre operatively with reasonable accuracy by operating surgeon.

Comprehensive risk score of more than 0.9 is significantly associated with incidence of post operative anastomotic leak at 1% level (p value <0.01). With nine readily available variables E-PASS scores can be calculated easily before surgery. If the comprehensive score is more than 0.9 surgeons can decide about doing a minimal procedure in emergency setting and do intestinal anastomosis after improving the physiological status of the patient.

It is also noted in the study that mean value of CRS in patient who died in post operative period is 1.14. Mean CRS value of alive patients is 0.5. Thus increasing value of CRS is also correlates with mortality rate.

CONCLUSION

- Incidence of anastomotic leak in gastro intestinal surgeries is around 18%.
- Anastomotic leaks occur more commonly in men than women.
- Emergency surgeries are significantly associated with anastomotic leaks than elective surgeries.
- Most common cause associated with anastomotic leak is mesenteric ischemia.
- Impaired pulmonary function is significantly associated with anastomotic leaks than other co morbid factors. Hence resuscitation and improving pulmonary status improves outcome in surgeries involving intestinal anastomosis.
- Incidence of anastomotic leak is also associated with prolonged stay in hospital and high mortality rates.
- All the three scores computed in E-PASS scoring system namely Pre operative Risk Score, Surgical Stress Score and Comprehensive Risk Score are significantly associated with incidence of anastomotic leak.
- Comprehensive Risk Score of more than 0.9 is significantly associated with anastomotic leaks. In all patients undergoing anastomotic surgeries E-PASS scores should be calculated prior to surgery and if CRS is more than 0.9 alternative options for anastomosis should be considered.

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PROFORMA

I. Basic Details:

Name of the patient:	
Age (in years) :	Sex: M / F
In patient Number :	Weight (in kg):
Diagnosis:	
Elective / Emergency:	
Surgery Done:	
Duration of Hospital Stay:	

II. History:

i. Chief Complaints

ii. Duration

iii. History of present illness

iv. Past History

   a. History of Pulmonary Disease

   b. History of Diabetes

   c. History of Heart Disease

   d. History of previous surgeries

v. Personal History

a. History of smoking / alcoholism

III. General Examination:

i.	Pulse rate :
ii.	Blood Pressure :
iii.	Respiratory Rate :
iv.	Temperature :

IV. Examination of Abdomen:

i. Inspection

ii. Palpation

iii. Percussion

iv. Auscultation

v. Per Rectal Examination

V. Other System Examination:

i. Cardio vascular system

ii. Respiratory system

VI. Clinical Diagnosis:

VII. Intra Operative Details:

i.	Duration of Operating Time:
ii.	Type of incision:
iii.	Findings:
iv.	Procedure Done:
v.	Approximate amount of blood loss:

VIII. Post operative Follow up:

IX. E-PASS scoring Calculations:

A. PREOPERATIVE RISK SCORE (PRS):

Age in years (F1) :	
Heart Disease (F2) :	Absent (0) Present(1)
Lung Disease (F3) :	Absent (0) Present(1)
Diabetes (F4) :	Absent (0) Present(1)
Performance Status index (F5) :	0 1 2 3 4
ASA Class (F6) :	1 2 3 4 5

Pre operative Risk Score = -0.0686 + 0.00345(F1) + 0.323(F2) + 0.205(F3) + 0.153(F4) + 0.148(F5) + 0.0666(F6)

B. SURGICAL STRESS SCORE (SSS):

1. Approximate blood loss:	Weight:	Blood loss/kg (F1):
2. Operating Time (in hours) (F2):		
3. Extent of Incision (F3):	Minor(0) Laparotomy (1) Thoracotomy(2)	

Surgical Stress Score = -0.342 + 0.0139(F1) + 0.0392(F2) + 0.352(F3)

C. Comprehensive Risk Score (CRS):

Comprehensive Risk Score = -0.328 + 0.936 (PRS) + 0.976 (SSS)

ABBREVIATIONS:

GI – Gastro intestinal

E-PASS – Evalualtion of Physiological Ability and Surgical Stress

PRS – Preoperative Risk Score

SSS – Surgical Stress Score

CRS – Comprehensive Risk Score

EEA – End to end Anastomosis

GIA – Gastro Intestinal Anastomosis

TA – Thoraco Abdominal

DJ – Duodeno-Jejunal

SD – Standard Deviation

DF – Degree of Freedom

TGF – Transforming Growth Factor

ASA – American Society of Anesthesiologists

INFORMED CONSENT

DEPARTMENT OF GENERAL SURGERY

Coimbatore Medical College, Coimbatore

I have been invited to participate in research project titled **" Prediction of Anastomotic Leak in Gastro intestinal surgeries using Evaluation of Physiological Ability and Surgical Stress (E-PASS) Scoring"**

I understand, I will be answering a set of questionnaire, undergo physical examination, investigations and appropriate treatment. I also give consent to utilise my personal details for study purpose and can be contacted if necessary. I am aware that I have the right to withdraw at any time which will not affect my medical care.

Name of the participant :

Signature :

Date :

ஒப்புதல் படிவம்

பெயர் :

பாலினம் :

முகவரி : வயது :

அரசு கோவை மருத்துவக் கல்லூரியில் பொது மருத்துவ துறையில் பட்ட மேற்படிப்பு பயிலும் மாணவர் **மரு. பா. பிரதீப்** அவர்கள் மேற்கொள்ளும் "**கோயமுத்தூர் மருத்துவ கல்லூரி மருத்துவமனையில் E-PASS மதிப்பீட்டு முறையை பயன்படுத்தி இரைப்பை மற்றும் குடல் பகுதியில் செய்யப்படும் குடல் இணைப்பு அறுவை சிகிச்சைகளில் வரும் கசிவு பற்றிய** " ஆய்வில் செய்முறை மற்றும் அனைத்து விவரங்களையும் கேட்டுக் கொண்டு எனது சந்தேகங்களை தெளிவுபடுத்திக் கொண்டேன் என்பதை தெரிவித்துக் கொள்கிறேன்.

நான் இந்த ஆய்வில் முழு சம்மதத்துடன், சுய சிந்தனையுடனும் கலந்து கொள்ள சம்மதிக்கிறேன்.

இந்த ஆய்வில் என்னுடைய அனைத்து விபரங்கள் பாதுகாக்கப்படுவதுடன் இதன் முடிவுகள் ஆய்விதழில் வெளியிடப்படுவதில் ஆட்சேபனை இல்லை என்பதை தெரிவித்துக்கொள்கிறேன். எந்த நேரத்தில் அந்த ஆய்விலிருந்து நான் விலகிக் கொள்ள எனக்கு உரிமை உண்டு என்பதையும் அறிவேன்.

இடம் : கையொப்பம் / ரேகை

நாள் :

MASTER CHART

Sl No	Patient name	IP No.	Diagnosis	Surgery done	Sex	Age	*Heart Disease*	Pulmonary Disease	Diabetes mellitus	Performance status index	ASA Score	Blood loss/body weight (ml/kg)	Operation time in hours	Extent of skin incision	(PRS)	(SSS)	(CRS)	Anas. Leak	Duration of stay (days)	Mortality
1	Thirumoorthy	32328	Carcinoma ascending colon	Extended Right Hemicolectomy	M	60	*0*	0	0	3	2	10	2	1	0.72	0.23	0.563744	No Leak	32	
2	Chandrasekaran	46263	Obstructive jaundice	Triple bypass	M	62	*0*	0	1	1	3	10	3	1	0.65	0.27	0.5369512	No Leak	27	
3	Duraisamy	57110	Acute intestinal obstruction ?enteric TB	Right Hemicolectomy	M	55	*0*	1	0	4	4	12	3	1	1.18	0.29	1.0680732	**Leak**	40	✓
4	Murugan	70946	Periampullary carcinoma	Whipples procedure	M	48	*0*	0	1	2	3	16.6	5	1	0.75	0.44	0.79632704	**Leak**	50	
5	Lalbagadhur	18739	Carcinoma stomach	Anterior Gastrojejeunostomy	M	45	*0*	0	0	1	2	4	1	1	0.37	0.1	0.1185924	No Leak	20	
6	Radhakrishnan	24918	Ileal Gangrene - mesenteric ischaemia	Resection and anastomosis of ileum	M	55	*0*	0	1	3	4	5	1.5	1	0.98	0.14	0.7285196	No Leak	41	
7	Mayilal	3329	Strangulated femoral hernia	Resection and anastomosis of small bowel	M	45	*0*	0	1	3	4	18.75	2.5	1	0.95	0.37	0.9210248	**Leak**	25	
8	Gayathri	60418	Periampullary carcinoma	Whipples procedure	M	55	*0*	0	0	3	2	20	4	1	0.7	0.44	0.7597804	No Leak	45	
9	Kanagavalli	26394	Carcinoma stomach	Distal partial gastrectomy	M	40	*0*	0	0	2	3	17.5	1.5	1	0.57	0.31	0.505588	No Leak	40	
10	Muthupandi	17109	Adhesive intestinal obstruction	Resection and anastomosis of small bowel	M	17	*0*	0	0	2	2	3.63	0.75	1	0.42	0.09	0.152118432	No Leak	10	
11	Kanagaraj	9517	Pseudocyst of pancreas	Roux-en-y cystojejunostomy	F	45	*0*	0	0	1	2	9.09	1.5	1	0.37	0.2	0.206774976	No Leak	39	
12	Karupannanan	51148	Periampullary carcinoma	Whipples procedure	F	63	*0*	0	0	2	3	14.65	3.75	1	0.64	0.36	0.62727856	No Leak	40	
13	Raju	54192	Carcinoma stomach	Anterior Gastrojejeunostomy	F	60	*0*	0	0	2	3	3.63	1	1	0.63	0.1	0.362876432	No Leak	63	
14	Selvaraj	58947	Ileo caecal mass ?TB	Right Hemicolectomy	M	42	*0*	1	0	3	3	1.3	2.25	1	0.93	0.12	0.65137312	No Leak	14	
15	Manthiriyappan	20704	Ileo caecal mass ?TB	Right Hemicolectomy	M	75	*0*	1	0	3	3	13.21	2.5	1	1.04	0.29	0.929077344	**Leak**	30	
16	Achikannu	28872	Carcinoma stomach	Distal partial gastrectomy	M	60	*0*	0	0	2	3	7.14	2.5	1	0.63	0.21	0.467883296	No Leak	30	
17	Selvavinayagam	38263	Strangulated right inguinal hernia	Resection and anastomosis of small bowel	M	26	*0*	0	0	3	2	1.66	1.25	1	0.6	0.08	0.312113024	No Leak	21	
18	Chinnammal	6240	Acute small bowel obstruction - adhesions	Resection and anastomosis of small bowel	M	60	*0*	0	1	2	3	6.35	2.5	1	0.79	0.2	0.60037384	No Leak	12	
19	Kanchana	15673	Adhesive intestinal obstruction	Resection and anastomosis of	M	46	*0*	0	0	3	3	4.237	1.7	1	0.73	0.14	0.493124837	No	14	

				small bowel									5					Leak		
20	Kasiammal	75410	Strangulated incisional hernia	Resection and anastomosis of small bowel	F	70	*0*	0	1	3	3	5.1	1.5	1	0.97	0.14	0.71597664	No Leak	33	
21	Senthil	72536	Blunt abdominal injury	Resection and anastomosis of small bowel	M	35	*0*	0	0	3	2	10	1.75	1	0.63	0.22	0.4734492	No Leak	24	
22	Sudarraj	73960	Carcinoma stomach	Distal partial gastrectomy	F	44	*0*	0	1	2	2	11.67	2.5	1	0.67	0.27	0.558542288	No Leak	30	
23	Ravi	77930	Pseudocyst of pancreas	Cystogastrostomy	F	40	*0*	1	1	2	2	4.167	2	1	0.86	0.15	0.616587189	No Leak	10	
24	Dhandapani	5437	Adhesive intestinal obstruction	Resection and anastomosis of small bowel	F	60	*0*	1	0	3	3	4.807	2	1	0.99	0.16	0.747511285	No Leak	22	
25	Gunasekaran	8359	Acute small bowel obstruction - adhesions	Resection and anastomosis of small bowel	M	30	*0*	0	0	3	2	4	1.5	1	0.61	0.12	0.36634	No Leak	12	
26	Kamaraj	45583	Pseudocyst of pancreas	Cystogastrostomy	M	40	*0*	0	0	2	3	3.225	2	1	0.57	0.13	0.33105724	No Leak	8	
27	Vijayakumar	7804	Ileo caecal tuberculosis	Ileo transverse anastomosis	M	36	*0*	1	0	3	4	5.55	1.75	1	0.97	0.16	0.73286312	No Leak	18	
28	Jothimani	25912	Carcinoma colon	Left hemicolectomy	M	51	*0*	0	1	3	3	10.41	2.5	1	0.9	0.25	0.764918624	No Leak	31	
29	Pushpa	69631	Gastric outlet obstruction	Anterior Gastrojejeunostomy & Vagotomy	M	40	*0*	0	0	3	3	4.34	1.5	1	0.71	0.13	0.465582176	No Leak	50	
30	Mahalakshmi	60453	Pseudocyst of pancreas	Cystogastrostomy	M	13	*0*	0	0	1	1	4.44	2	1	0.19	0.15	-0.002851184	No Leak	35	
31	Chinnapalani	27057	Intestinal obstruction - Mesenteric ischemia	Resection and anastomosis of small bowel	M	50	*0*	1	1	3	3	10	2.5	1	1.11	0.25	0.9480072	**Leak**	22	
32	Shahul hameed	35672	Carcinoma stomach	Anterior Gastrojejunostomy	F	46	*0*	0	0	2	3	4.44	1.5	1	0.59	0.13	0.347786016	No Leak	20	
33	Maniyal	69022	Carcinoma head of pancreas	Triple bypass	F	57	*0*	0	1	3	3	11.11	3	1	0.92	0.28	0.812919904	No Leak	45	✓
34	Vasantha	11935	Carcinoma stomach	Distal Gastrectomy - Billroth 2 anastomosis	F	65	*0*	0	0	2	3	15	4.5	1	0.65	0.39	0.6671796	No Leak	40	
35	Kandiyathal	15209	Small bowel gangrene - SMA occlusion	Jejunocolic anastomosis	M	45	*1*	1	1	4	4	4.16	**2.5**	1	1.63	0.17	1.355827024	**Leak**	50	✓
36	Eswari	19704	Carcinoma stomach	Distal Gastrectomy - Billroth 2 anastomosis	M	45	*0*	0	1	2	3	10	4	1	0.74	0.31	0.658842	No Leak	32	
37	Durgadevi	50879	Pseudocyst of pancreas	Cystogastrostomy	F	20	*0*	0	0	1	2	3.26	2	1	0.28	0.13	0.066082464	No Leak	21	
38	Jemini	31193	Periampullary carcinoma	Whipples procedure	F	57	*0*	0	1	3	3	40	7	1	0.92	0.84	1.35789	**Leak**	45	✓
39	Iyammal	11873	Carcinoma stomach	Distal Gastrectomy - Billroth 2 anastomosis	F	40	*0*	0	0	2	3	10	3.5	1	0.57	0.29	0.4803584	No Leak	30	
40	Rukmani	36781	Carcinoma caecum	Right Hemicolectomy	F	50	*1*	0	0	3	3	5	2.5	1	1.07	0.18	0.8474152	No Leak	20	

41	Chinnal	61141	Carcinoma stomach	Anterior Gastrojejunostomy	F	65	*0*	0	0	2	3	1.92	1.5	1	0.65	0.1	0.374953488	No Leak	25	
42	Haldurai	50496	Ileal Gangrene - mesenteric ischaemia	Resection and anastomosis of small bowel	M	48	*1*	0	0	3	4	7.14	2	1	1.13	0.19	0.913196896	No Leak	13	
43	Jaibunisha	45550	Strangulated femoral hernia	Resection and anastomosis of small bowel	F	65	*0*	1	0	3	4	5.55	2	1	1.07	0.17	0.83607472	No Leak	18	
44	Hakkim	49976	Acute intestinal obstruction - Ileal TB	Resection and anastomosis of small bowel	F	30	*0*	0	0	2	3	2	1.5	1	0.53	0.1	0.2630168	No Leak	15	
45	Kamalam	48485	Periampullary carcinoma	Whipples procedure	F	40	*0*	0	0	2	3	13.63	4.5	1	0.57	0.38	0.567863632	No Leak	35	
46	Sundarammal	49562	Strangulated incisional hernia	Resection and anastomosis of small bowel	M	40	*0*	0	1	3	3	4	1.5	1	0.87	0.12	0.6041776	No Leak	13	
47	Murugan	29791	Blunt abdominal injury	Resection and anastomosis of small bowel	F	27	*0*	1	0	4	4	20	2	1	1.09	0.37	1.0479276	**Leak**	40	
48	Ganapathy	46997	Carcinoma Ascending colon	Right Hemicolectomy	M	78	*0*	1	0	3	3	4.16	2	1	1.05	0.15	0.796859424	No Leak	40	
49	Durairaj	49528	Carcinoma stomach	Anterior Gastrojejunostomy	F	53	*0*	0	0	0	4	2.5	1.5	1	0.38	0.1	0.1293532	No Leak	25	
50	Senthilkumar	48497	Carcinoma stomach	Distal Gastrectomy - Billroth 2 anastomosis	F	59	*0*	1	0	3	3	13.33	3.5	1	0.98	0.33	0.917297312	**Leak**	45	